Movements and Spatial Use Patterns of Radio-tagged West Indian Manatees (*Trichechus manatus*) along the Atlantic Coast of Florida and Georgia: A Progress Report

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INTRODUCTION

The West Indian manatee (*Trichechus manatus*) is a large, herbivorous aquatic mammal that lives in shallow estuaries, rivers and coastal areas of the New World tropics and subtropics (Lefebvre et al. 1989). The Florida subspecies (*T. m. latirostris*) occurs at the northern end of the species' range. Their low metabolic rate makes them susceptible to cold stress in winter, hence limiting their northward distribution and affecting their behavior and movements (Irvine 1983). During the warm-season, manatees can be found throughout the coastal areas and freshwater river systems of Florida and Georgia, but in winter most manatees aggregate around warm-water sources, either natural springs or industrial effluents, in central and southern Florida (Hartman 1979) (Fig. 1).

The Florida manatee is endangered because of its small population size, low reproductive rate, increasing human-related mortality, and the impacts of the burgeoning human population on coastal habitats (U.S. Fish and Wildlife Service 1996). While manatee numbers in some parts of Florida appear to have increased at a healthy rate in recent years, the population along the eastern seaboard has apparently grown slowly or remained stable (Eberhardt and O'Shea 1995; but see Garrott et al. 1994), probably as a result of excessive mortality from anthropogenic causes (Ackerman et al. 1995, O'Shea and Langtimm 1995). Evidence for a decline in the number and proportion of calves in this population since the early 1980's is also a serious concern, suggesting a decline in female fecundity or a rise in calf mortality (Reynolds and Wilcox 1994). Life-history data from photo-identification and radio-telemetry studies along the Atlantic coast indicate that reproductive rates seem comparable to those found in regions with growing manatee populations, but firm data on calf and subadult survival are lacking (Reid et al. 1995).

The Sirenia Project undertook a radio-telemetry study starting in 1986 to gather information on the ecology, behavior and life-history of manatees living along the Atlantic coast of Florida and Georgia (Sirenia Project 1992). The ultimate goal was to provide managers with solid data upon which to base decisions regarding the best ways to protect manatees and their habitats over this extensive region. At that time, manatee distribution and movements along the east coast were known primarily from aerial surveys of particular areas, anecdotal records based on interviews and opportunistic sightings, and on resightings of scarred, identifiable individuals. These studies documented a seasonal migratory pattern, with manatees moving into southeast Florida for the winter and dispersing northward for the warm season (e.g., Hartman 1974, Kinnaird 1985, Weigle et al. 1987, Reid et al. 1991). Aerial surveys in Brevard County, for example, found relatively low numbers in winter and rapid increases during the spring and fall, suggesting that a wave of migrants moved into central Florida during these seasons (Shane 1983, Provancha and Provancha 1988). Photo-identification records of uniquely scarred individuals up to 1986 confirmed the long-distance (> 500 km) seasonal movements of many manatees along the Atlantic coast and demonstrated individual site fidelity to winter aggregation sites (Reid et

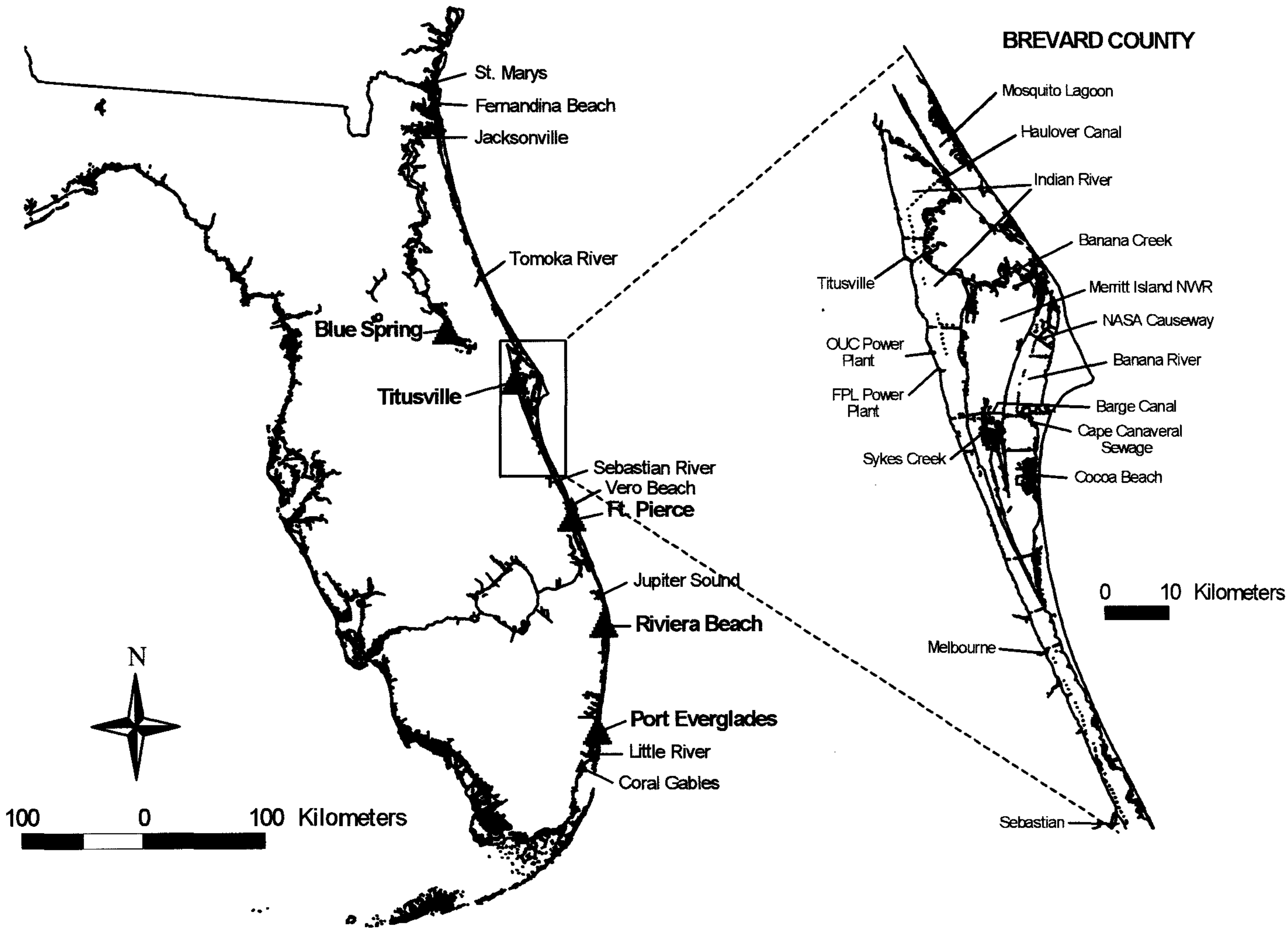

Figure 1. Place names of sites along the Atlantic coast of Florida and Georgia that were commonly used by manatees or that are mentioned in the text. Major and minor winter aggregation sites, mostly thermal effluents, are indicated by large and small triangles, respectively. Brevard County, the area most heavily utilized by tagged manatees in this study, is shown in detail.

al. 1991). This work also showed that manatees move among thermal refuges, both between and within winter seasons.

Radio-telemetry provides a different window on manatee biology than that provided by aerial censuses or photo-identification. Aerial surveys yield brief snapshots of the distribution of a large number of manatees in a given area, whereas telemetry provides an intensive time-series of the movements of a relatively small number of individuals. Aerial survey data can present a biased picture of manatee spatial use patterns when there is a distinct diel cycle to their movements (Rathbun et al. 1990) or when environmental (e.g., water turbidity) and behavioral (e.g., diving pattern) factors that are known to affect manatee visibility vary substantially among surveyed areas (Lefebvre et al. 1995). Photo-identification is valuable in documenting gross movements of individuals over long periods of time (Reid et al. 1991) but it lacks the fine temporal resolution of movements provided by radio-tracking methods, and data collection is necessarily opportunistic, especially outside of the cold season. During the 1970's and early 1980's radio-telemetry was used successfully to track manatee movements in other regions of Florida—including the upper St. John's River (Bengtson 1981), the Big Bend area on the Gulf coast (Rathbun et al. 1990), and southwest Florida (Lefebvre and Frohlich 1986)—but these early studies relied principally on field-monitored VHF transmitters and were limited in their spatial and temporal extent (see O'Shea and Kochman 1990 for overview). Typically, animals were tagged at a thermal refuge in the winter and then tracked until the tag detached or the battery failed, usually sometime in the summer or fall of the same year. The Atlantic coast telemetry project departed from previous studies in a number of important ways. First, it has relied heavily on satellite-monitored transmitters, yielding an approximate ten-fold increase in the frequency of locations compared to a VHF tracking study, and the temporal and spatial distribution of fixes are not biased by observer accessibility. The study animals were still tracked in the field, however, to provide information on reproductive status, activity, habitat use and tag condition. Second, it has encompassed the entire range of the Atlantic coast population, from the Florida Keys to Georgia, so inferences are not limited to a small geographic area. Third, the study has spanned a decade, permitting an examination of interannual variation in movement patterns as a function of winter severity, reproductive status and other factors. Many of the same individuals have been tracked for a large portion of this period, providing precise measures of female reproductive parameters (Reid et al. 1995) as well as allowing us to determine within-animal variation in seasonal movements, site fidelity and spatial use patterns. The strength of this research program lies in its emphasis on long-term, longitudinal tracking of individuals.

Much of the work accomplished over the course of this Research Work Order involved the development, refinement and quality control of spatial databases relating to manatee radio-telemetry. While many of the problems and limitations in interpreting and analyzing manatee distribution and movements from telemetry data were anticipated (White and Garrott 1990, Deutsch 1994), others were only discovered after thorough scrutiny of the databases. The general approach that I have taken in analyzing these large and complex sets of data follows.

(1) Update Existing Databases: This was a continuing process, of course, but a large backlog of data had accumulated that required digitizing or time-consuming data processing.

(2) Create New Databases: It was necessary to create new databases on the characteristics of tagged manatees and on water temperature in order to extract particularly useful information from the principal telemetry locational databases. The tagged manatee identity database, for example, has allowed me to create subsets of the data on migratory movements by sex, age class and rehabilitation status. Several databases on hourly water temperature at different sites within the study area will be valuable in examining temperature-induced changes in manatee movements.

(3) Improve and Implement Quality Control of Databases: This effort involved clarification of variable definitions, standardization of data collection protocols, improvements in computerized error-scanning routines, and development of new error-detection programs.

(4) Characterize the Databases: A thorough description of each database was required, including variable definitions, database structure, sampling effort, current status of updates, and the limitations and biases of individual variables and of the database as a whole. Descriptive statistics are provided to characterize each database.

(5) Analyze Annual Patterns of Movements: This work involves analyses of migratory behavior, including distance between summer and winter ranges, site fidelity, travel rates, and timing of long-distance seasonal movements in relation to temperature change. These movement variables are examined as a function of sex, age class and rehabilitation status.

(6) Analyze Within-season Movement Patterns: This work includes analyses of home range patterns, power plant use in winter, and relationships of spatial use patterns to environmental features (e.g., seagrass beds) using Geographic Information Systems (GIS), again as a function of individual attributes.

I will describe the progress made in each of these categories and indicate work that still remains to be done. Substantial progress has been made toward completing the most important tasks in the first four categories, that is, in creating, preparing and describing high-quality telemetry databases for analysis. Relatively less effort has been directed toward spatial analyses. The time period covered is from May 1986 through May 1996 (December 1986 to September 1995 for the satellite-determined locations). Since this work is still in progress, all results are preliminary and subject to modification.

METHODS

Study Area

Our study area encompassed the entire east coast of Florida and southeast Georgia, including inland waterways such as the lower St. John's River (Fig. 1). Habitats used by tagged manatees along this 750-km stretch of coastline varied widely and included: rivers, canals, estuaries and the ocean close to shore; freshwater, brackish and marine water bodies; polluted rivers in highly modified urban environments; relatively undisturbed mangrove swamps, salt marshes, and seagrass flats; and human-created features, such as marinas, residential canal systems, thermal industrial effluents, and freshwater sewage effluents.

Capture, Tagging and Radio-tracking of Manatees

A total of 83 manatees were radio-tagged and tracked along the Atlantic coast between 8 May 1986 and 31 May 1996. Most (n = 48, 57.8%) of these animals were tagged and released in the Indian River lagoon system in Brevard County along the central Florida coast (Fig. 2). The remainder were tagged in about equal numbers in south Florida (n = 16, 19.3%), including three in the Florida Keys, and in north Florida and southern Georgia (n= 19, 22.9%). One additional manatee (TBS-01, "Bertram"), tagged and released at Blue Spring and tracked briefly in the upper St. John's River system in 1995, is not included in this study. Figure 2 shows the number tagged and released at each specific location.

About half of the study animals (n = 42) were initially captured alongshore and restrained with nets; three of these involved rescues of manatees in distress, followed by immediate release on site. Another 17 free-ranging manatees were initially belted and tagged by a researcher snorkelling quietly up to the unrestrained animal while it was resting. Twenty manatees in this study had been rescued and brought into captivity because they were sick, severely injured, or found as orphans; after a period of rehabilitation at oceanaria, these animals were radio-tagged and released, usually near the point of original capture (Bonde et al. 1995). Four additional animals were born and raised in captivity. Specific information on capture location, release location, and method of capture is listed for each individual in Appendix 1b.

The tag and harness assembly consisted of a floating radio-transmitter attached with a 4-foot, flexible nylon tether to a padded belt that fit snugly around the manatee's peduncle (for details, see Rathbun et al. 1987 and Reid and O'Shea 1989). Two types of radio-transmitters were used in this study: very-high frequency (VHF) transmitters and ultra-high frequency (UHF) transmitters, known as platform transmitter terminals (PTTs). Twenty-one manatees carried only the smaller, field-monitored VHF tags, while 62 animals were tracked using combinations of VHF tags and the larger, satellite-monitored PTTs. Most of the PTT tags contained a weaker VHF transmitter within the housing, permitting the manatees to be tracked in the field. In the latter part of the study, sonic transmitters were also incorporated into the housing to provide a means by which field personnel could locate a sunken tag or a manatee whose radio-transmitter had ceased functioning. The battery life of these transmitters was approximately 2 years for VHF tags and 8-9 months for PTTs. Radio-transmitters that had little

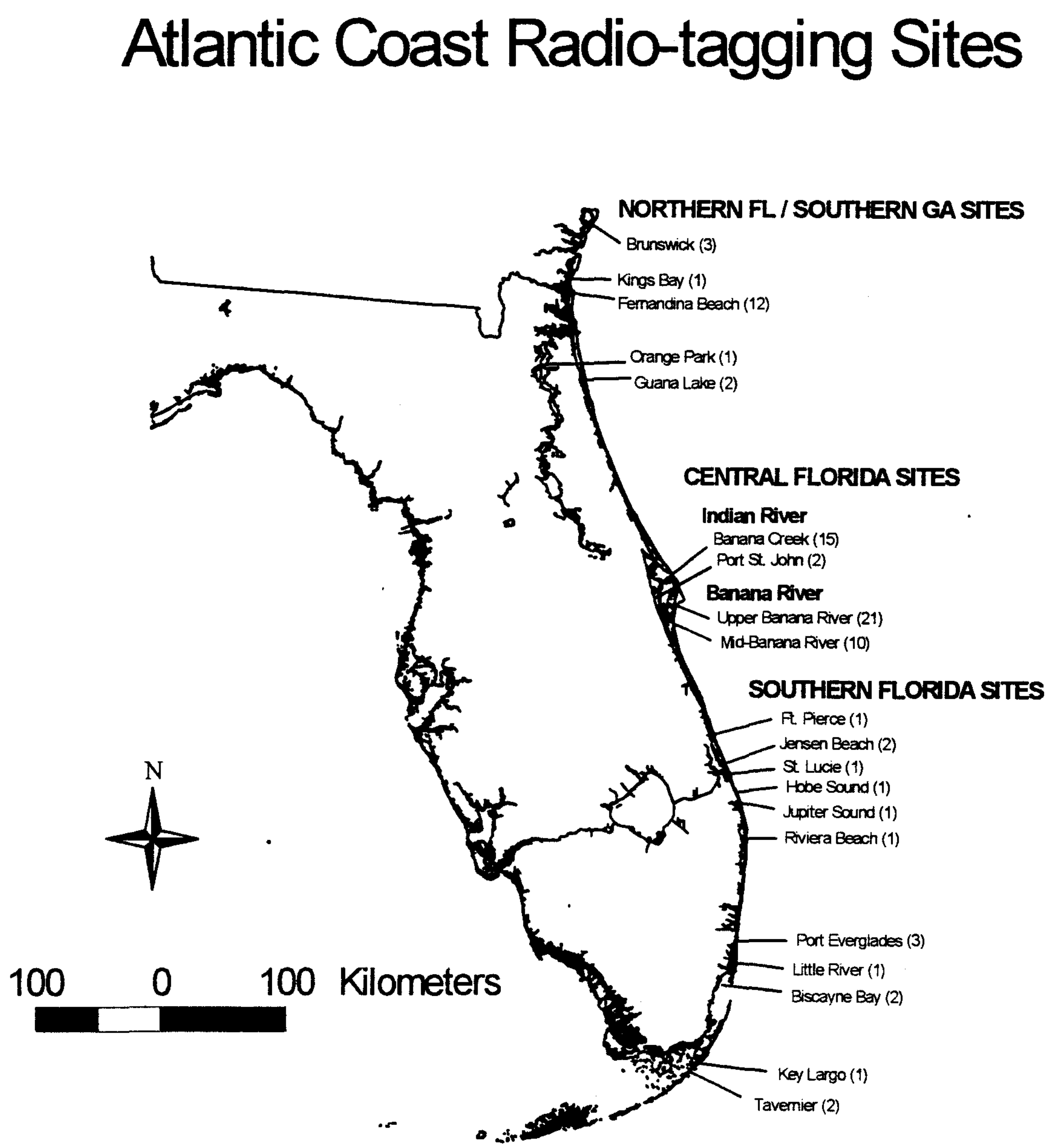

Figure 2. Locations of initial tagging and release sites for 83 manatees tracked along the Atlantic coast of Florida and Georgia. The number of manatees initially tagged at each site is given in parentheses. An additional 347 retagging events took place throughout the study area.

battery life remaining, that were encrusted with barnacles (and hence sinking), or that had electronic or physical malfunctions were often removed and replaced with a fresh tag by researchers snorkelling up to the manatee; this resulted in the maintenance of continuous tracking bouts of individuals that were longer than the battery life of the tag. Radio-tags frequently became detached at the designed weak link in the base of the tether, which ensured that the manatees could free themselves from a potential tag entanglement. Field researchers have been very successful in relocating and reattaching tags to these manatees, usually without recapturing the animal, thus allowing many individuals to be tracked intermittently over a considerable period of time. A total of 54 (65%) of the study animals have been tracked over multiple tag deployments.

VHF Tracking Methods and Data Collection

All manatees were tracked from shore, by boat, or occasionally by single-engine airplane using conventional VHF radio-tracking equipment about once or twice per week. The locations of visual sightings were plotted in the field on copies of USGS quadrangle maps or NOAA nautical charts (source map scales = 1:24,000 and 1:40,000, respectively). Locations of tagged manatees that could not be determined visually were estimated using triangulation or were recorded as general areas (i.e., a polygon which enclosed the probable location). In addition, sightings of tagged manatees made by the public were included after verification of information. The following data were recorded on tracking maps in the field: individual identification, date, location(s) and movements, time(s), observer(s), observation platform (boat, truck or plane), precision of location (visual point location, triangulation, general area polygon), bearing and signal strength (for non-visual locations), manatee group size, presence/absence of calf, animal activity, condition of transmitter housing, tether and belt, and sometimes associated environmental information (e.g., water temperature, salinity).

PTT Tracking Methods and Data Collection

The satellite-monitored radio-tags transmitted data to two (or three) polar-orbiting Tiros-N NOAA weather satellites and the data were processed by Service Argos' Data Collection and Location System (DCLS) (Service Argos, Inc. 1990). Platform locations were calculated from the Doppler shift in the perceived frequency of the transmitted signal as the satellite approached and then moved away from the animal. Service Argos provided the following data for each satellite pass over a transmitting PTT: PTT ID number, date, time (GMT), latitude and longitude (for the WGS-84 datum) in decimal degrees, location quality, number of transmitter messages received, ID of satellite that received message, and a variety of requested sensor data (see below). With Argos' Location Class Zero Service (LC0, formerly called Animal Tracking Service) we were able to access the following information as well: number of messages received with signal strength greater than -120 dB, the best signal strength of any message, the two possible location solutions (located at equal distances on either side of the satellite's ground track), and specific information on oscillator drift within and between satellite passes that can account for poorer locational accuracy. See Fancy et al. (1988) and Harris et al. (1990) for excellent descriptions of the Argos DCLS and its application to tracking wildlife.

PTT Location Quality

Satellite-determined locations were reported to the nearest 0.001 degree latitude and longitude, constraining locational precision to approximately 100 m; consequently, telemetry locations displayed on a relatively small area that is heavily used by tagged manatees appear as a grid of points spaced at 100-m intervals. A number of factors associated with the geometric conditions of the satellite's orbit (e.g., distance of satellite ground track from PTT, error in orbital determination) and the PTT itself (e.g., signal strength, number of messages, stability of frequency of transmitted signal) contributed to the error of the estimated locations from their true locations. Since 1986, Service Argos has provided a location class (LC) as a measure of the relative accuracy of each location. While Argos has improved its methods of location determination, the meanings of the location classes and the algorithms used to assign them have changed over the course of this study. The major changes are summarized here.

During the first several months of this study, through 31 March 1987, Argos defined a Location Calculation Quality Index (NLOC) as follows:

Time Period: <01Dec86 - 31Mar87

NLOC	Meaning
-1	= PTT not located, last location determined from 1 pass only.
0	= PTT not located.
1	= Location determined from 2 passes of same satellite.
2	= Location determined from 2 passes, one by each satellite.
3	= Location determined from 1 pass only.

Information on the accuracy and precision of locations associated with these location quality indices is provided in Fancy et al. (1988). As one would expect from the above criteria, the mean error of NLOC3 locations is substantially greater than that of NLOC1 or NLOC2 locations.

In April 1987, Service Argos introduced a different location classification system based on improved software for processing locational data from PTTs. Most of the data in our PTT database conform to the following location classes, sometimes also termed location quality indices (LQ or NQ):

Time Period: 01Apr87 - 14Jun94

LC	Precision (1 SD)	Required Conditions
3	150 m	≥ 5 messages, ≥ 420 sec between 1st & last messages, very good oscillator stability & geometric conditions.
2	350 m	≥ 5 messages, ≥ 420 sec between 1st & last messages, good oscillator stability & good geometric conditions.
1	1000 m	≥ 4 messages, ≥ 240 sec between 1st & last messages, reasonable oscillator stability & good geometric conditions.
0	None given	≥ 2 messages, pass duration <240 sec, oscillator unstable, or satellite ground track too close or too far from PTT.

The Sirenia Project started receiving LC0 service for manatee tracking in November 1987; it was essentially a "catch-all" class for any locations rejected by the other classes. Precision is measured as RMS (root mean square) Error, which is equal to one standard deviation of the locational errors. Service Argos' technical bulletins claim that 68% of locations would lie within a circle of radius equal to the RMS error around the true location. The error is apparently applied to the latitudinal and longitudinal components separately, however, resulting in a square (not a circle) that contains approximately 68% of the observations (Chris Estes, Service Argos, pers. comm.). Note that the highest accuracy under this system was obtained with a LC3, whereas a location quality index of 3 (NLOC3) under the previous classification system gave the poorest accuracy. To clarify the different meanings given by these classification systems, all location classes prior to 1 April 1987 have been prefaced with an 'X' (e.g., LC = 'X3' instead of '3').

The second major change in the way that location classes were determined and reported occurred on 15 June 1994. Now location classes 1-3 mean basically the same as in the previous system, although the algorithm for classification has been greatly changed. The original LC0 was redefined and has essentially been subdivided into four classes (0, A, B, Z), the latter three of which became available under Argos' Auxiliary Location Processing. The company claims that most of the new LC0 locations are accurate to within 5000 m. Service Argos has not rigorously defined its criteria for classification but has provided the following information in its bulletins.

Time Period: 15Jun94 - Present (31May96)

LC	Precision (1 SD)	Required Conditions
3	150 m	≥ 4 messages, ≥ 2 of the 4 plausibility tests are passed.
2	350 m	≥ 4 messages, ≥ 2 of the 4 plausibility tests are passed.
1	1000 m	≥ 4 messages, ≥ 2 of the 4 plausibility tests are passed.
0	>1000 m	≥ 4 messages, ≥ 2 of the 4 plausibility tests are passed.
A	None given	3 messages, 2 of the 4 plausibility tests are done.
B	None given	2 messages, 2 of the 4 plausibility tests are done.
Z	None given	Unvalidated Location. <2 of the 4 plausibility tests are done. Implausible velocity, transmitter frequency instability, or satellite passed directly overhead the platform.

Service Argos introduced the plausibility tests to ensure that the more plausible of the two possible locational solutions is given as the platform location (Service Argos 1995). The four types of plausibility checks are: (1) Check that the frequency calculation for the assumed correct location is more plausible than that for the assumed image location (requires ≥ 4 messages); (2) check that the calculated transmitted frequency of the chosen locational solution is closer to the previous calculated frequency (which must be < 12 hr old) than that of the assumed image location ; (3) compare the distances of the chosen and assumed image locations to the previous validated location; and (4) check the mean transmitter speed since the previous location.

PTT Sensor Data

The satellite-monitored radio-tags provided information about the manatee's behavior and environment, as well as its location. Depending on the hardware incorporated into the PTT and how it was programmed, between three and seven types of sensor data were provided with each location. Data were collected on the following variables: (1) PTT temperature; (2) short-term (1-hr) activity index; (3) long-term (12-hr) activity index; (4) low battery voltage flag; (5) average PTT dive time over a 4-hr period; (6) PTT dive count over a 4-hr time period; and (7) saltwater switch fail-safe flag. The temperature sensor provided counts that must be converted to temperature in degrees Celsius using a PTT-specific temperature calibration curve provided by Telonics, Inc. The accuracy of the temperature sensor is given as approximately ± 2 °C (B. Burger, Telonics, Inc.). The insulating effect of the tag cannister results in a time lag between temperature change in the water and in that reported by the PTT; furthermore, the housing is subject to the influence of solar radiation (resulting in an overestimate of temperature when the tag remains at the surface on sunny days), warming by the electronic circuitry, and possibly to evaporative cooling on windy days (potentially resulting in an underestimate of temperature). Technical information on each of these sensor types and the way in which the data were formatted in the Argos data transmission stream are provided in Appendix 2.

PTT Duty Cycles

The NOAA satellites pass over the Florida region an average of 9 times (range, 8 - 12) per 24-hr period, each overpass lasting about 10 minutes (Fancy et al. 1988). To optimize the tradeoff between maximizing the number of locations per day and conserving battery power (hence extending PTT longevity), a duty cycle was programmed into each PTT. This turned the units on at predetermined intervals that corresponded to the four relatively fixed periods that satellites passed over the region. Most PTTs used since 1987 were programmed with the following optimum duty cycle: 2 hr On - 4 Off - 2 On - 3 Off - 2 On - 6 Off - 2 On - 3 Off. The transmitters sent messages for a total of 8 hr over each 24-hr period, providing us with locations during four 2-hr time periods per day. The duty cycle would start when a magnet was removed from the outside of the cannister; the turn-on time was varied between 0630-0900 hr EST in order to correspond to changes in the timing of satellite overpasses. For a PTT started at 7 AM, the periods of transmission were 0700-0900 hr, 1300-1500 hr, 1800-2000 hr, and 0200-0400 hr. The PTT's internal clock has sometimes drifted by as much as 0.5 hr over its deployment period, thus shifting the duty cycle slightly. Two other duty cycles were utilized in the early years of the study; details on these and on recent changes in turn-on times are provided in Appendix 3.

PTT Data Access

PTT location and sensor data were acquired from Argos' Data Processing Center in a number of ways. The data that was developed into our spatial databases and used in all analyses was sent to the Sirenia Project on 9-track tapes (December 1986 - September 1989) or diskettes (since October 1989) on a monthly basis. Project staff usually queried the Argos data every day using personal computers and modems in order to monitor the manatees' movements and tag condition (as indicated by the battery flag and activity sensors). In recent years, two-day compilations of PTT data were also provided via electronic mail over the Internet. Methods of data processing are described below.

Radio-telemetry Databases: Description, Current Status, Sample Sizes, and Improvements in Quality Control

There are four principal databases associated with the radio-telemetry study of manatees along the Atlantic coast of Florida and Georgia: (1) the Tagged Manatee Identity Database provides data on the attributes of the study animals; (2) the Tagging History Lookup Table gives information on all tagging and retagging events for each individual, including dates and reasons for detachment; (3) the VHF Radio-telemetry Database provides locational and behavioral data on manatees tracked in the field; and (4) the PTT Radio-telemetry Database provides the bulk of data on manatee locations, as determined from satellite-monitored radio-transmitters. Another PTT database that will not be discussed in this report comprises locational data collected from fixed radio-tags during two separate experiments designed to determine the accuracy and precision of the locations provided by Service Argos. All of the above data are maintained as permanent SAS databases at the Sirenia Project, although the tagging history lookup table is entered and also maintained as a dBase III file. The spatially referenced datasets have also been incorporated into a GIS, specifically ARC/INFO and ArcView (Environmental Systems Research Institute (ESRI)), for map creation and spatial analysis of distribution and movements in relation to environmental features. Each database is described in detail below, including the following information: database structure and variables; current status of updates; sample sizes; improvements made to data collection and data entry protocols; improvements made to database quality control procedures; and other work accomplished. Information in each database is further characterized by descriptive statistics, tables and figures.

1. Tagged Manatee Identity Database: Attributes of Study Animals

In order to analyze the telemetry data by individual attributes, it was first necessary to create a permanent SAS database (tagmanid.sd2) that included the following data for each tagged manatee: identification number, name, sex, captive before tracking bout?, dates of capture and tagging/release, duration in captivity, capture and tagging/release locations, capture method, age class at capture and tagging/release, and total length at capture and tagging/release. It also includes data on number of days tracked and percent of tracking period (i.e., period from initial tagging to last day with tag) with functioning transmitter for each manatee through 31 May 1996. For free-ranging manatees, date, location, age class and length have the same values at capture and at tagging/release, and duration in captivity equals zero months. This information, when merged with the VHF and PTT telemetry databases by ID, allows the generation of data subsets according to sex, age/size class, and rehabilitation status. A complete printout of the tagged manatee identity database is given in Appendix 1a,b.

Our sample of radio-tagged manatees included 32 males (38.6%) and 51 females (61.4%); at initial tagging, most animals were adults (n = 66, 79.5%), followed in number by subadults (n = 12, 14.5%) and dependent calves (n = 5, 6.0%) (Table 1). Four of the five calves were tracked with their mothers and subsequent to weaning; one female calf (TBC-39) was only tracked while dependent on its mother, so the effective sample size of independent tagged animals is 82. The mean (± SD) total length at tagging and release was 285 (± 32) cm and ranged from 200 to 350 cm (Fig. 3). The smallest independent animal, an orphan (TBC-34) held in captivity for 8 months, was only 219 cm at release.

Fifty-nine (71.1%) of the study animals were free-ranging at initial capture and tagging. Of the 24 manatees (28.9%) that were tagged and released after rehabilitation in captivity, most were male (n = 14, 58.3%) and adult at time of tagging (n = 17, 70.8%) (Table 1). Half (n = 12) of the captive group of animals were adults at the time they were rescued from the wild and brought into captivity; two were subadults, one was a dependent calf (with its mother), five were orphaned calves, and four were born in captivity (Table 2). One of the captive-born manatees (TBC-39) was tagged and released with its mother at an age of 10 months, while the other three were released as independents at ages of 2.4 to 5.0 years. The duration that these rehabilitated manatees had spent in captivity at oceanaria before release ranged from 6 days to 7.1 years, with a median duration of 8.6 months (Fig. 4). Most rehabilitated manatees (n = 14, 58.3%) had been in captivity for less than one year and three (12.5%) had been captive for over 5 years (Fig. 4).

The identity database is current and verified through 31 May 1996. It needs to be expanded to include data on: year of birth (for calves), the approximate dates that individuals change age classes (from calf to subadult and from subadult to adult), and additional length measurements and associated dates after initial capture and release. A reproductive status database for tagged adult females also needs to be developed so that movements and habitat use can be easily compared between females with and without calves and analyzed as a function of calf age. The information on number of days tracked and percent tracking period currently in the identity database will be removed once a separate database created from the tagging history lookup table is completed.

2. Tagging History Lookup Table

Information on tagging and retagging events is found in the tagging history lookup table, which encompasses all manatees tagged with PTT and VHF radio-tags by the Sirenia Project since 1986, including the Atlantic coast of Florida and Georgia (n=83), the upper St. John's River (n=1), Puerto Rico (n=8), southwest Florida (n=3), and test PTTs used in the locational accuracy experiments. Data are entered and maintained as a dBase III file and then converted to a SAS database (lkuptags.sd2); a printout of the Atlantic coast and test PTT records is provided in Appendix 4a. The lookup table contains data on the following 13 variables: animal identification number, name, tag number (VHF tags have 3 digits, PTTs have 4 or 5 digits), bout number (0 for VHF tags, numbered sequentially for PTTs), date and time tag was deployed, comment about deployment or redeployment (e.g., net tag, free tag, replace tag), estimated or

Table 1. Number of radio-tagged manatees along the Atlantic coast of Florida and Georgia over the period of May 1986 to May 1996 by age class at tagging, sex and captive status prior to tagging.

	AGE CLASS AT TAGGING											
	Calf			Subadult			Adult			Total		
	M	F	All	M	F	All	M	F	All	M	F	All
Free-range	2	1	3	3	4	7	13	36	49	18	41	59
Captive	1	1	2	4	1	5	9	8	17	14	10	24
Total	3	2	5	7	5	12	22	44	66	32	51	83

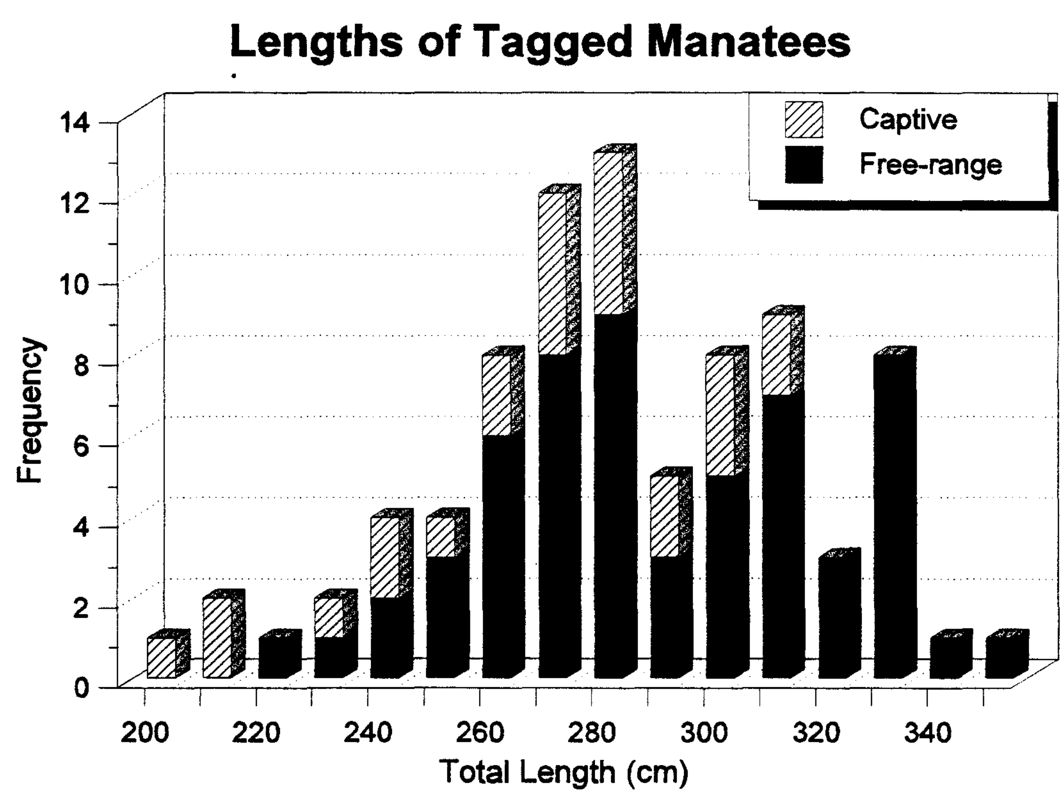

Figure 3. Frequency distribution of lengths of wild-caught and captive rehabilitated radio-tagged manatees along the Atlantic coast of Florida and Georgia.

Table 2. Number of radio-tagged manatees along the Atlantic coast of Florida and Georgia over the period of May 1986 to May 1996 that had been captive prior to tagging according to age class at start of captivity and sex.

	AGE CLASS AT START OF CAPTIVITY					
	Dependent Calf					
	Captive-born	Wild-born Orphan	Wild-born with Mother	Subadult	Adult	Total
Male	3	5	1	0	5	14
Female	1	0	0	2	7	10
Total	4	5	1	2	12	24

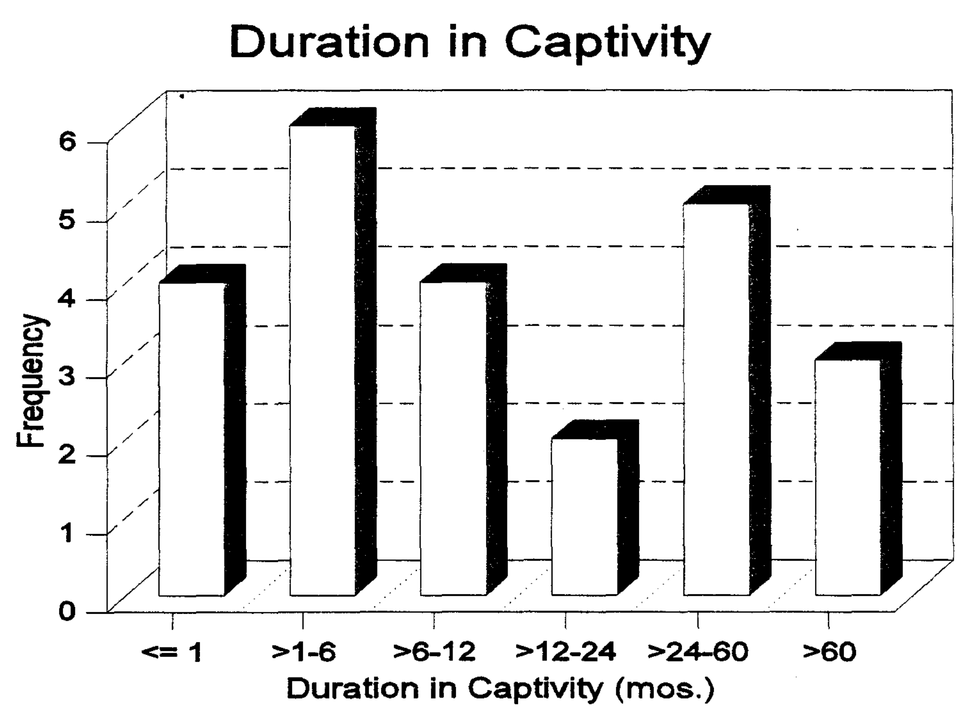

Figure 4. Frequency distribution of the duration that rehabilitated and captive-born manatees spent in captivity prior to radio-tagging and release on the east coast of Florida.

known date and time tag was replaced or detached, comment about detachment, termination code (e.g., replace transmitter, tag lost and tether broken at weak link, tag struck by boat), belt size and color of nylon webbing, and tether strength.

The dates and times of PTT locations are "looked up" for a given tag number against the tagging history database to filter out locations from non-deployed PTTs and to assign the correct manatee ID and name to locations from deployed PTTs. The accuracy of the information (especially tag number, deployment and detachment dates and times) in this database is therefore crucial to the construction of an accurate PTT radio-telemetry database; one error in the tagging history database can result in numerous serious errors in the PTT database. Three types of procedures were implemented to assure quality control of this relatively small but important database. First, the tagging history database was scanned in SAS (program by H. Kochman) for logical errors in dates and times (e.g., ondate/time is later than offdate/time for a given deployment; ondate/time is earlier than offdate/time of previous deployment), for unusually long deployment durations (i.e., >270 days), and for problems that may arise from the conversion of dBase to SAS files. In addition, frequency tables of animal IDs and names were examined to ensure that only one name was used for each ID number and vice-versa. Potential errors detected with these scans were checked and corrected. Second, the dates and times of deployment and detachment were carefully proofed against the tagging history files for each manatee. Third, we realized that because the date and time of tag recovery was often used for the date and time of detachment, especially in the older records, this resulted in the inclusion of locations from detached, drifting radio-tags in the PTT database. To remedy this problem, the locational and sensor data from each premature detachment (e.g., from break of tether at the designed weak link) were scrutinized to estimate the date and time on which we were reasonably certain that the tag was still attached to the manatee; the 12-hr activity sensor typically reported zero tips after detachment. A hypothetical example will illustrate the process: turn-on time for the PTT duty cycle was 0700 hr; tag was recovered at 1600 hr, 10 Jan.; Argos data indicated zero tips on the long-term activity counter since 1930 hr, 8 Jan.; a moderate long-term tip count was reported for two prior locations on 8 Jan. (0800 and 1400 hr) but it is important to realize that this indication of activity refers to the previous 12-hr reporting period (1900 hr, 7 Jan. to 0700 hr, 8 Jan.); and accessory information (i.e., short-term activity count, movement distances) are then used, when possible, to estimate the time window within this 12-hr period in which detachment occurred. Estimates are conservative to minimize the likelihood of locations from detached PTTs being included in the database; records from detached PTTs were then purged from the PTT database. This process could not be employed for VHF tags and so some of the deployment durations are likely to be slightly inflated; however, this does not affect the validity of data in the VHF telemetry database, which is not dependent on the tagging history lookup table.

The tagging history lookup table is now updated and verified through 31 May 1996. The following changes were also made to this database: (a) The animal identification field has been changed from the old 'S-#'s (originally used to differentiate satellite-monitored individuals from those with only VHF tags, which were denoted with 'T-#'s) to 'T-#'s for all records. (b) PTTs used in the locational accuracy tests are denoted by a leading 'X' in the identification field; this includes tags deployed on captive animals in the acclimation pens along the NASA causeway. (c) Animals tagged by the FDEP (formerly FDNR) on Florida's West coast (term code = '88') were removed from the database.

The tagging history database provides a great deal of information on the tagging program. Each record represents one tagging event or one "take," as defined by the Marine Mammal Protection and Endangered Species Acts, and each tag deployment is referred to as a "tagging bout." Through May 1996, there have been 430 successful tagging or retagging events (n = 188 for VHF, n = 242 for PTT) on the Atlantic coast (excluding the upper St. John's River), for a median of 3.0 tagging bouts per study animal (Table 3). The maximum number of tagging bouts for one manatee (TBC-09, "C-cow") was 39. Excluding six deployments that were still ongoing at the end of the study period, the median duration that individual tags remained on the subjects was 27.0 days (range, <1 - 578 days) for VHF tags and 70.5 days (range, <1 - 250 days) for PTTs; one adult male carried a PTT past the end of the study period for a total of 282 days. Many of the very short durations for VHF tags involved their use as interim "safety" tags until a satellite-monitored tag could be substituted. Most consecutive tagging bouts (61.7%, n = 214/347) were separated by intervals of less than or equal to 24 hr (n = 210 intervals lasted < 1 hr), meaning that the durations of continuous tracking bouts for individual manatees were considerably longer than indicated by the durations that particular tags remained on an animal. Continuous tracking bout durations were highly variable, lasting up to 2.7 years for one individual (TFP-02, "Ross"). Some manatees were tracked intermittently over long periods of time; adult female TBC-24 ("Betty"), for example, was tracked for 92% of the time over a 6.1-year period! The median total duration that study subjects were tracked was about 7 mos., but this ranged from 2 days to 6.8 yrs (Table 3). The median interval between continuous tracking bouts was 71.8 days but this was highly variable, ranging up to 2861 days (7.8 years) (Table 3).

The most common reason for the termination of the tagging bout was to replace the transmitter with another one; this was done for a number of reasons, including low battery life, electronic or physical malfunction, and simply to replace a VHF tag with a PTT (Table 4). The next most common cause of termination was the detachment of the tether at the designed weak link, presumably after the tag had become snagged on something. Occasionally, humans or alligators were responsible for the tag detachment. Twenty of the tagging bouts were terminated by boat strikes to the transmitter housing, the tether or the belt. Seven other bouts ended with the death of the tagged manatee, but none of these deaths were attributable to the presence of the radio-tag or attachment system.

Over the 10-year time span of this research effort, 83 manatees along the Atlantic coast carried VHF tags for 10,264 days and PTT tags for 20,547 days, for a grand total of 30,812 days, equivalent to 84.4 animal-years (Table 5). Figure 5 illustrates the pronounced shift from predominantly field-based VHF tracking during the first half of the study to predominantly satellite-based tracking during the second half (see also Table 5). Note that manatees carrying PTTs, however, continued to be tracked in the field from the VHF transmitters incorporated in

Table 3. Descriptive statistics on the number of tagging bouts per manatee, tagging bout duration, duration of intervals between tracking bouts, and total number of days tracked per individual. Data are included for both VHF and PTT transmitters deployed along the Atlantic coast of Florida and Georgia over the period of May 1986 to May 1996. All durations are in days.

	Mean	Median	Std Dev	Min	Max	Sum	N
No. Tagging Bouts[1]	5.2	3.0	6.9	1	39	430	83
Tagging Bout Duration[1,2]	71.2	51.7	69.5	< 1	578	30812	424
Duration of Intervals between Tracking Bouts[3]	167.7	71.8	309.8	1	2861	22298	133
Total No. Days Tracked[4]	371.2	215.7	449.3	2	2475	30812	83

[1] A tagging bout refers to a single transmitter deployment.
[2] Tagging bouts (n = 6) that were ongoing at the end of the study period (31 May 1996) were excluded from these analyses (except for the calculation of Sum, where n = 430).
[3] A tracking bout refers to one or more consecutive tagging bouts, separated by no more than 24 hours; 98% (210/214) of tagging bouts within a tracking bout were separated by < 1 hr.
[4] The total number of days that a manatee had a functioning radio-tag.

Table 4. Causes of termination of 424 radio-tagging bouts along the Atlantic coast of Florida and Georgia over the period of May 1986 to May 1996, grouped into eight major categories (see Appendix 4b for specific categories). Frequency and percent of occurrence and the median and maximum tagging bout duration (in days) are listed for each termination cause. Data for both VHF and PTT transmitters are included.

Cause of Tagging Bout Termination	N	%	Tagging Bout Duration: Median	Tagging Bout Duration: Maximum
Replaced Transmitter	209	49.3	64.1	578
Replaced Belt and Transmitter	10	2.4	53.2	121
Recovered Transmitter: Tether or Hardware Broke	138	32.5	41.3	192
Recovered Belt and Transmitter: Belt Broke	12	2.8	85.1	192
Removed Belt and Transmitter	8	1.9	32.5	250
Lost Transmitter	34	8.0	54.6	172
Manatee Rescued	6	1.4	70.6	130
Recovered Dead Manatee with Tag	7	1.7	77.5	134

Table 5. Radio-tracking effort by year and tag type, including number of radio-tagged manatees, number of days manatees were carrying transmitters, number of locations, and number of days with locations. Manatees were tracked along the Atlantic coast of Florida and Georgia from May 1986 to May 1996. The PTT telemetry database currently contains locations from December 1986 through September 1995; the number of tag-days and the number of manatees represented by this period is given in parentheses when it differs from the actual number over the full the ten-year period.

	Year of Study											
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Total
All Tag Types												
No. Manatees Carrying Tags	5	18	20	20	24	24	26	24	23	19	11	83
No. "New" Manatees Tagged	5	14	8	11	10	7	8	4	4	10	2	83
Total No. Tag-days	266 (108)	1856	2678	2713	3192	4545	4781	3668	3344	2890 (2330)	880 (3)	30,812 (29,218)
VHF Tags												
No. Manatees Carrying VHF Tags	2	16	17	18	19	17	16	12	5	5	2	60
No. VHF Tag-days	46	1380	2038	1655	1579	2323	891	93	120	135	3	10,264
No. VHF Locations*	94	917	1784	1908	1515	2262	1506	752	449	429	194	11,810
% Visual Sightings	93.6	50.8	62.5	78.0	79.4	76.4	82.7	80.6	84.9	90.4	97.9	75.3
No. Tag-days with VHF Locations	73	620	1040	1244	1183	1866	1202	598	363	267	130	8,586
% Total Tag-days with VHF Locations	27.4	33.4	38.8	45.9	37.1	41.1	25.1	16.3	10.9	9.2	14.8	27.9

(Table continued on next page)

Table 5 (continued)

	Year of Study											
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Total
PTT Tags												
No. Manatees Carrying PTT Tags	5 (2)	5	9	12	17	18	22	23	22	18	11 (0)	62 (61)
No. PTT Tag-days	220 (62)	476	640	1058	1612	2222	3890	3575	3224	2755 (2195)	876 (0)	20,547 (18,953)
No. PTT Locations	103	942	1629	3252	5449	7118	11592	9330	9380	8893	--	57,688
% "Guaranteed" Locations† ‡	49.5	81.8	84.8	100.0	100.0	100.0	100.0	100.0	80.0	71.5	--	91.5
No. Tag-days with PTT Locations†	32	349	554	1024	1565	2141	3700	3317	2903	1994	--	17,579
% PTT Tag-days with PTT Locations†	51.6	73.3	86.6	96.8	97.1	96.4	95.1	92.8	90.0	90.8	--	92.8

NOTE: The number of tag-days is rounded to the nearest integer, so the sum across years or across tag types may not exactly equal the total.

* Includes 1250 (10.6%) sightings from the public.

† Location classes 1, 2, and 3 (and X1, X2, and X3 for 1986 to early 1987 data) only.

‡ This percentage represents the location classes in the current PTT database, not the raw data sent by Service Argos. From September 1988 to mid-June 1994, LC0 records were sent in a separate file by Argos and these were not merged into the main PTT database. Starting on 15 June 1994, all non-guaranteed locations (0, A, and B) were included with the guaranteed locations in the Argos file.

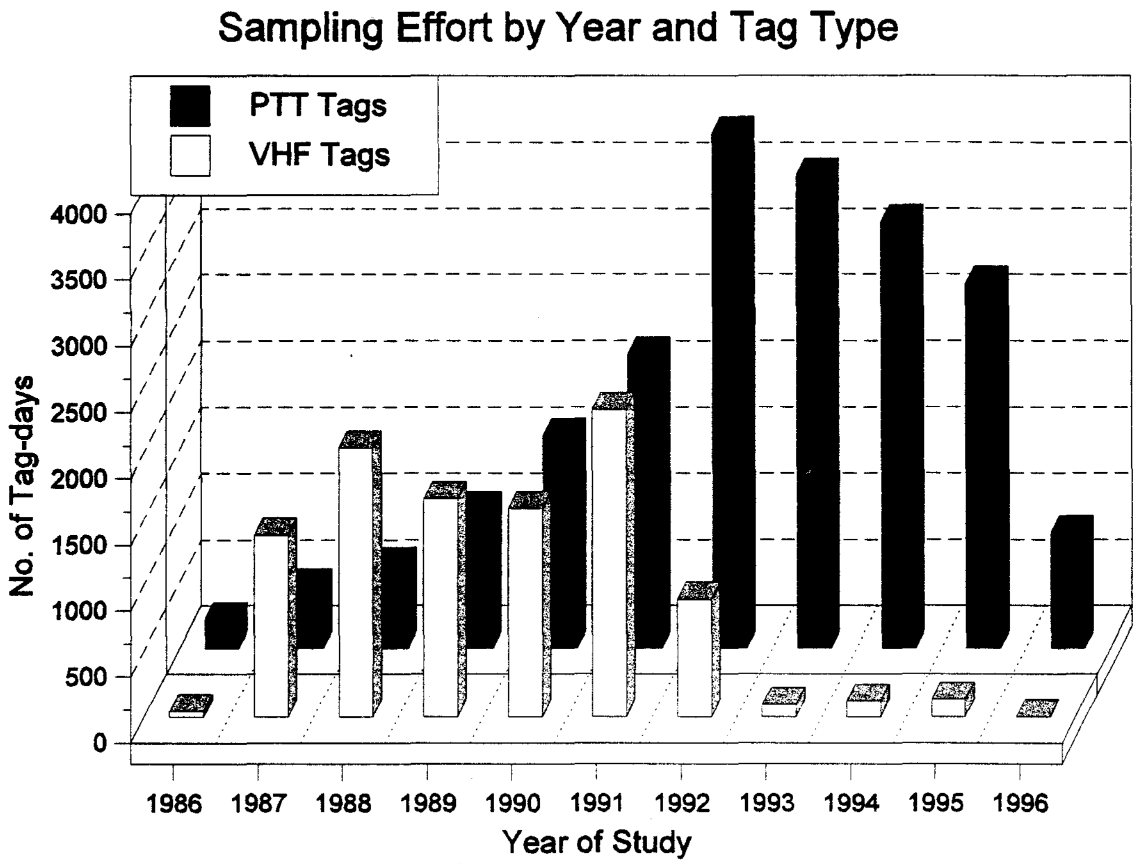

Figure 5. Radio-tracking effort by year and tag type, measured in terms of the cumulative number of days manatees carried functioning radio-tags along the Atlantic coast from May 1986 to May 1996.

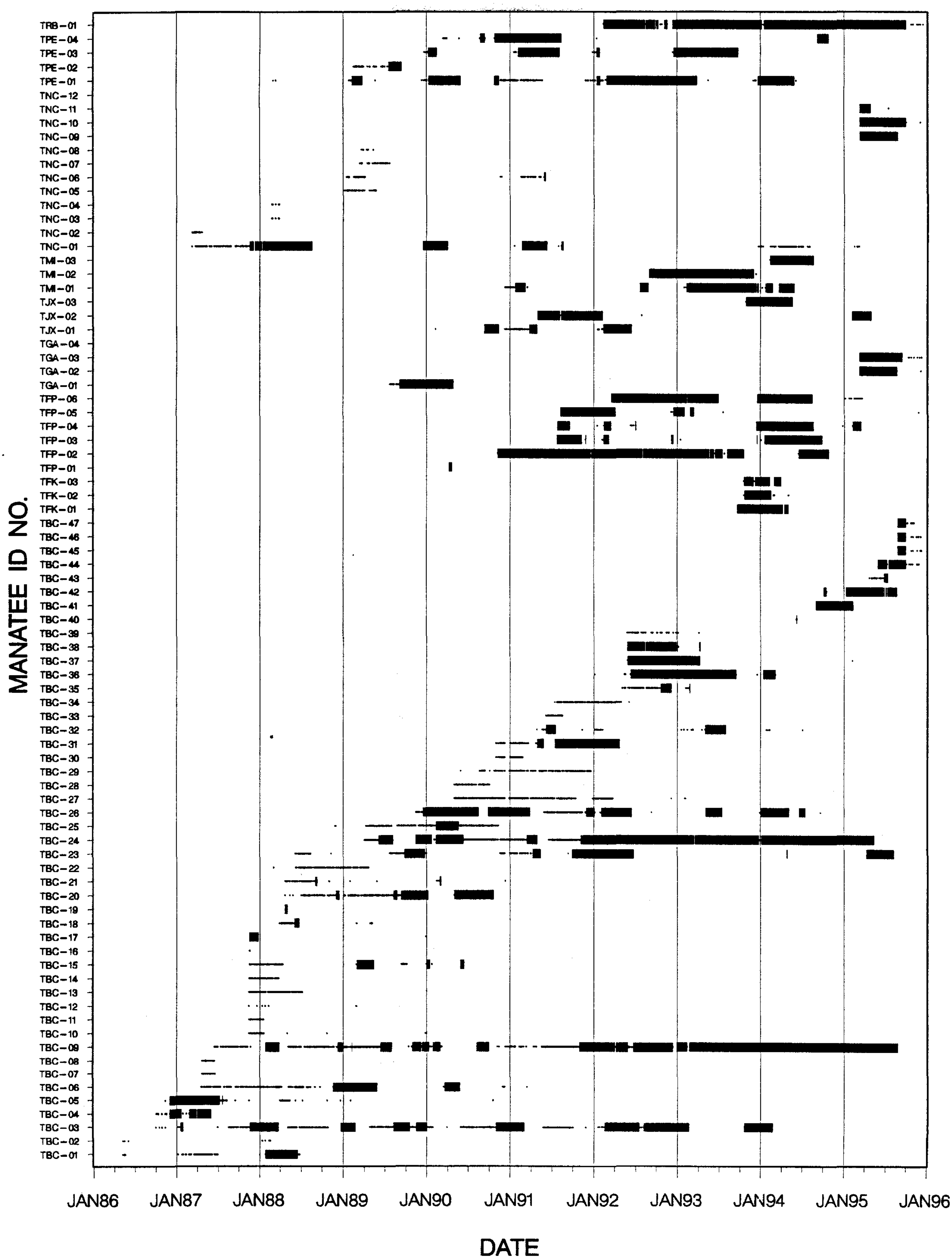

Figure 6. Radio-tracking records of Atlantic coast manatees by tagtype (PTT = | , VHF = .) from 1986 through 1995.

the PTT cannisters. Between 18 and 26 manatees were tracked in each full year of the study (1987-1995) (Table 5). Many individuals were tracked over multiple years, as illustrated in Figure 6. This is also reflected in the generally declining number of "new" manatees tracked each year (Table 5).

3. Field-monitored VHF Radio-telemetry Database

VHF location records of tagged manatees (including belt-only sightings) were entered into ASCII files from data recorded on the field tracking maps, and the locations were digitized on 1:24,000-scale USGS quadrangle maps. The data were then imported into SAS and subjected to a series of error-scans; after correcting the errors revealed by the scans, two permanent SAS databases were created (see below). These SAS databases contain information on the following variables: manatee identification number, manatee name, date, local time (EST or EDT), precision of location (PCODE = visual point location, triangulation, or general area polygon), number of digitized points (>1 for polygons), type of observation (staff or public), duration manatee spent at the digitized location, manatee group size, presence of calf, tagged manatee activity, quadrangle name, and location (UTM coordinates for zone 17 in the NAD-27 datum). Continuous observations of a tagged animal that changed locations were indicated in the PCODE field as a first location (e.g., 'PF'), optional center location(s) (e.g., 'PC'), and a last location (e.g., 'PL').

Implementation of Database Quality Control Procedures: Computerized Error-scanning

Three SAS programs were employed to check for the following types of logical errors in the VHF ASCII and SAS databases: incorrect formatting (e.g., missing space between variable values), duplicate records, more than one ID number or name for a given manatee, inappropriate or extreme values for the variables, incorrect or incomplete sequence of PCODES for continuous observations, and unreasonable locations (as indicated from a crude X-Y plot of UTM coordinates). After an update dataset had been scanned and corrected, it was merged with the main SAS database and the error-scans were run again. Other types of errors, such as incorrect manatee IDs or dates, were more difficult to detect. We are in the process of developing a new SAS routine to detect these errors by comparing the dates and times of locations in the VHF telemetry database to the starting and ending dates and times of tagging bouts in the tagging history lookup table. Visual inspection of latitude versus date plots showing annual movement patterns (see Results) has also been useful in identifying potential errors that were not detected with the computerized scans.

Processing of General Area Locations

Each general area location was composed of several records (n = 2 to 33) in the original database (atlvhfrw.sd2), each corresponding to a vertex of the estimated polygon. To make these observations compatible with the rest of the point locations in the database, a centroid (ie., visual center) was calculated for each general area polygon with a SAS routine; when the number of points was only two, (used occasionally for non-visual locations in narrow canals), the mid-point of the line was taken as the estimated point location. The raw general area data were then saved to a separate database (atlvhfar.sd2) and the centroid data were merged back with the visual locations and triangulations to create the principal VHF point database (atlvhfpt.sd2). The following variables were added to each general area location in the VHF point database to provide an index of the relative accuracy of the estimated centroid: Area in hectares of the location polygon; mean distance (m) of the centroid to the polygon vertices; and maximum distance (m) of the centroid to a polygon vertex.

Problems and Improvements in Data Collection and Data Entry Protocols

I identified a number of problems with the attribute data in the VHF telemetry database that resulted from inconsistencies in data collection and data entry protocols. Some of these problems stemmed from a lack of clear, standardized definitions or criteria. Four variables with such inconsistencies are discussed below. These problems have either been rectified or are not serious in terms of their effect on the overall integrity value of the VHF database.

Manatee Activity

A list of manatee activity categories and their corresponding database codes were established at the beginning of the telemetry project, but as the study progressed more activities were added and the meanings of certain terms diverged across the multiple observers. So while recorded activities were consistent within observers, there were sometimes disparities among observers in what the activity categories meant. By consensus among field staff and with input from the literature (Hartman 1979, Bengtson 1981, Zoodsma 1991), we standardized and clearly defined activity categories and codes for radio-tracking data collection and data entry in late 1994. Appendix 5 provides the complete list of activities and their definitions; seven new categories were added (four being subcategories of two former ones) and three categories were deleted. This effort eliminated inconsistencies since that time, but we still had to deal with past problems in the database. Observations with activities that had been interpreted variously in the past were verified against field tracking maps and the activity codes were modified, as necessary, to standardize usage. This lengthy process has resolved most of the problems with the activity variable. In addition, the size of the activity field in the database was changed to permit up to three activities to be coded for a given location (previously it was limited to only one activity).

The following modifications to activity codes in the VHF database have been completed: (a) The code "Multiple" was deleted and replaced with up to three characters denoting the sequential order of observed activities; (b) the code "Other" was replaced with the appropriate code in current use (e.g., categories such as "Socialize" were at one time coded as "Other") and it now indicates a tagging event or attempt by a researcher; (c) the category for a human (non-researcher) feeding a tagged manatee was changed from "Feed" to "Human Feed"; (d) the most problematic activity category, "Idle", was deleted from usage and replaced with either "Mill", "Rest", or "Slow Travel", depending on the description of the activity on the tracking map and on the identity of the observer; (e) the seldom-used category "Loiter" was deleted and replaced with "Mill"; (f) a new category "Mating Herd" was added by checking all tracking maps with activity codes of "Other", "Multiple", "Socialize" or "Cavort" for possible mating activity; and

(g) activity categories used by B. Zoodsma in her thesis research (Zoodsma 1991) were converted into Sirenia Project codes prior to merging her Georgia VHF data with the principal database.

Use of habitat and home range will be analyzed as a function of gross activity categories that combine some of the finer divisions noted in Appendix 5. For example, resting will include bottom rest and surface rest activities, travelling will include slow and fast travel, and socializing will include cavorting and mating. More specific questions could also be addressed, such as where manatees go to drink freshwater and how they respond (in terms of movements) to tagging interactions with researchers.

Precision Code

The PCODE variable gives information on both the relative precision of the location and on whether it was an isolated sighting or one of a continuous series of locations. There have been no clear criteria for deciding between the latter two possibilities when two or more locations are recorded for the same manatee on a given day by the same observer. Generally, if the manatee was under continuous observation, the locations are listed as PF, PC ... PC, PL. This is a minor problem because the times of the locations will be used when determining their independence for statistical purposes (e.g., home range calculation). Nevertheless, I recommend that a series of locations be indicated as continuous only if there are no gaps greater than 1 hr duration in observation.

Duration at Location

This variable indicates the number of minutes that the researcher observed the tagged manatee at the digitized location. There has been some variation among data entry staff over the years as to how duration was calculated when applied to a continous series of locations, however, including the following methods: the entire observation duration given for the first location and missing durations for subsequent locations; the duration of the interval between consecutive points given for each location; and the actual duration the animal spent at each location, which may have been minimal (or not recorded) for a travelling manatee. The latter method was the intended one. Without referring back to the 531 original maps that tracked animals over two or more locations, the inconsistency in calculation method makes this variable of little value in this context. The variable should be accurate for the vast majority (85.7%) of the records in the database, however, which consist of single locations.

Group Size

Group size in the SAS database is equal to the number of manatees in a group, including the focal tagged manatee but excluding its calf. For example, the group size of a single manatee or a solitary cow-calf pair is listed as one. The operational criteria for delineating a group, however, were not clearly defined; some observers counted manatees within a distance of approximately 10 m of the focal animal as comprising the group, whereas others estimated the number of manatees "in the general vicinity" (e.g., in the same residential canal). While neither of these definitions is wrong, the lack of standardization reduces the value of this variable;

perhaps it can be used to indicate whether the tagged manatee was solitary, in a small group, or in a large group (e.g., a power plant aggregation). I recommend the following definition of a manatee "group" in this application: the number of manatees within 10 m of the focal animal plus—using the "chain rule"—the number of additional manatees within 10 m of them, and so on; this would allow most of a large winter aggregation to be counted as part of the tagged manatee's group, even though it might be spread out over an area 50 m across.

Sources of Error in VHF Locations

There are three principal sources of error that contribute to the accuracy of a visual sighting of a tagged manatee. (1) The charts and maps used in the field have a small degree of inherent error, as well as error associated with natural or human-induced changes that have occurred since the original cartographic work was conducted. Furthermore, the coastline in the USGS quadrangle maps (used for digitizing) may not be completely concordant with the NOAA charts (from which the GIS coverage was digitized). There is little that we can do to reduce these errors, but we assume that they are negligible compared to other sources of error. (2) Error in plotting the animal's location on the map in the field is unknown but probably varies considerably with the manatee's distance offshore, the proximity to landmarks (e.g., islands, causeways) identified on the tracking maps, the observer's familiarity with the area, and other factors. (3) Digitizing error is the third component of the overall locational error. A preliminary assessment of this error source yielded the following results: (a) four manatee locations that were redigitized differed by an average Euclidean distance of 149 m; and (b) ten locations digitized on hardcopy quadrangle maps (i.e., the current method) and on-screen in ArcView (over a digitized NOAA shoreline coverage) yielded UTM coordinates that differed by an average of about 20-25 m (equivalent to 1 mm on a 1:24,000-scale quad map) (see Appendix 6 for details). The precision indicated by the first result was not satisfactory, but the sample size needs to be greatly increased before any conclusion can be made. The latter result suggests that the locations may be digitized on-screen in a GIS with approximately equal precision and accuracy as on a large-scale hard-copy map.

Current Status of the VHF Telemetry Database

A large backlog of tagged manatee locations has been digitized and processed up through 31 May 1996. There are still three major checks that needs to be completed before verification of the VHF database is complete: (1) confirmation that all VHF sightings (except belt-only observations) occurred within the tagging bouts specified in the tagging history lookup table; (2) identification and addition of researcher tagging events that were omitted from the database; and (3) comparison of the IDs, dates and times of locations in a printout of the entire database against the tracking maps to search for typos in these fields. All sighting times will then be converted to Eastern Standard Time. Numerous sightings by the public have not yet been plotted onto tracking maps and digitized, but given the lower reliability of these data and the relatively low benefit-to-cost ratio involved, this task has been deemed a low priority.

We gathered a total of 11,810 VHF locations on 8,586 different tag-days for 83 manatees over the entire study period (Table 5). Tagged manatees were located on 28% of total tag-days (range across years, 9.2 - 45.9%, Table 5), for an average of one location every 3.6 days (range across years, 2.2 - 10.9 days). (Note that this average excludes multiple sightings on the same day.) Field effort was necessarily greater during the first half of the study (1986-1991), as indicated by the higher sighting rate (39.5% of tag-days, or one location every 2.5 days), when primarily VHF tags were used, compared to the latter half of the study (1992-1996) when greater reliance on satellite-monitoring was made (16.4% of tag-days, or one location every 6.1 days). For 75.3% of the location fixes, manatees were visually sighted after "homing in" on the VHF signal (Table 5); the rest of the locations were either determined through triangulation (7.5%) or estimated as general area polygons (17.2%). The visual sightings included 1250 locations (10.6%) provided by the public and verified by Project staff.

4. Satellite-monitored PTT Radio-telemetry Database

Location and sensor data for each PTT were obtained from Service Argos on a monthly basis via nine-track tapes (Dec. 1986 - Sept. 1989) or diskettes (since Oct. 1989). SAS programs were used to extract the locational data from the raw Argos DS (dispose) files (ASCII format), to scan for formatting errors and duplicate records, to flag putative outliers, and to create a permanent PTT telemetry database. The tagging history lookup table (see above) was accessed by the SAS program when building the location database in order to match the PTT record to the correct manatee name and identification (ID) number, based on PTT ID number, date and time. Locations from non-deployed or detached PTTs were removed and archived in a separate dataset. Locations were converted from the WGS-84 datum to the NAD-27 datum and projected from geodetic coordinates (latitude and longitude) to Universal Transverse Mercator (UTM, zone 17) coordinates using the Geographic Calculator software (Blue Marble Geographics, Gardiner, ME) in order to be consistent with the mapping system used for the Florida shoreline and other existing GIS coverages. The current PTT telemetry database includes data on the following variables: manatee ID number, manatee name, PTT ID number, date, time (EST), tagging bout number (from the lookup table), latitude and longitude in decimal degrees (WGS-84 datum), UTM x (Easting) and y (Northing) coordinates (zone 17, NAD-27 datum), and location class. Location class zero and other non-guaranteed locations were included in the database for some years and not for others (Table 5), depending on how Argos provided these data.

Prior to January 1991 the PTT sensor data were extracted from the Argos DS files, processed to yield only one observation per location (i.e., one record per satellite pass, since the raw data give one record for each transmitted message), and stored as a separate ASCII data file. This sensor database included the following information: PTT ID number, date, time (which typically differed slightly from time in the location database), number of messages received, median PTT temperature (stored in a coded form that must be converted to degrees Celsius with PTT-specific regression equations), short-term activity index (modal no. minutes PTT tipped in a 1-hr period, max. = 60), and long-term activity index (modal no. times PTT tipped in a 12-hr period, max. = 1023). These and other sensor data (see Appendix 2) were still collected subsequent to January 1991, but they were not processed into one record per satellite pass and they were left in the raw Argos DS files.

Implementation of Database Quality Control Procedures

The PTT database had fewer quality control problems than the VHF database because it did not require as much of a human element in its creation. There were two principal types of potential error that differed in their origin and consequences. The first type of error was introduced by mistakes in the start and end times of tagging bouts listed in the tagging history lookup table. This resulted in the inclusion of locations from detached (presumably drifting, stranded or recovered) PTTs in the telemetry database and, occasionally, in the exclusion of valid locations from tagged manatees. The lookup table was scrutinized for errors, as described above, and has been verified for accuracy. Therefore, this source of error has been eliminated or at least minimized. The second type of error was inherent to the Argos system of PTT location determination. Locations were reported by Argos to the nearest 1/1000th of a degree latitude and longitude (approximately 100 m) but the locational error followed a probability distribution with a variance determined by the assigned location class (see section on Location Quality above). Potential outliers were identified as those lying outside a series of latitude-longitude windows (Fig. 7). Different series of these windows were used for tagged manatees in the Florida Keys, the Atlantic coast, and the upper St. John's River regions. Locations that were wildly wrong (e.g., southern hemisphere) were immediately deleted, while those in the vicinity of the study area were checked manually against other PTT and VHF locations to determine whether the locations were plausible for the individuals and dates in question. Putative outliers were then either verified as valid or deleted and archived in a separate database. Sometimes the alternate locational solution (on the opposite side of the satellite's ground track) was plausible and was substituted for the given location. Nearly all of the outliers were of non-guaranteed location classes (0, A, B), although a few location classes 1 and 2 were beyond acceptable bounds. Locations within the defined latitude-longitude windows might also be considered "outliers" for certain types of spatial analyses, such as calculation of travel rates or use of home range. We opted to keep such locations as they may be useful in delineating annual movement patterns (e.g., rapid migratory movements often result in poor location classes); the database can be trimmed further depending on the requirements of the particular spatial analyses being conducted.

Current Status of the PTT Telemetry Database

The verified satellite telemetry database now spans the period from 1 December 1986 through 30 September 1995. It will be updated through at least May 1996 by the end of the year. Additional locational data on five manatees along Florida's east coast were collected by satellite earlier in 1986 (two in May to June, three in September to November), but they were not included in the database because of compatibility problems associated with changes in Argos format. All but one of these manatees (TBC-02, "Trixie") were radio-tracked again during the period included in the database.

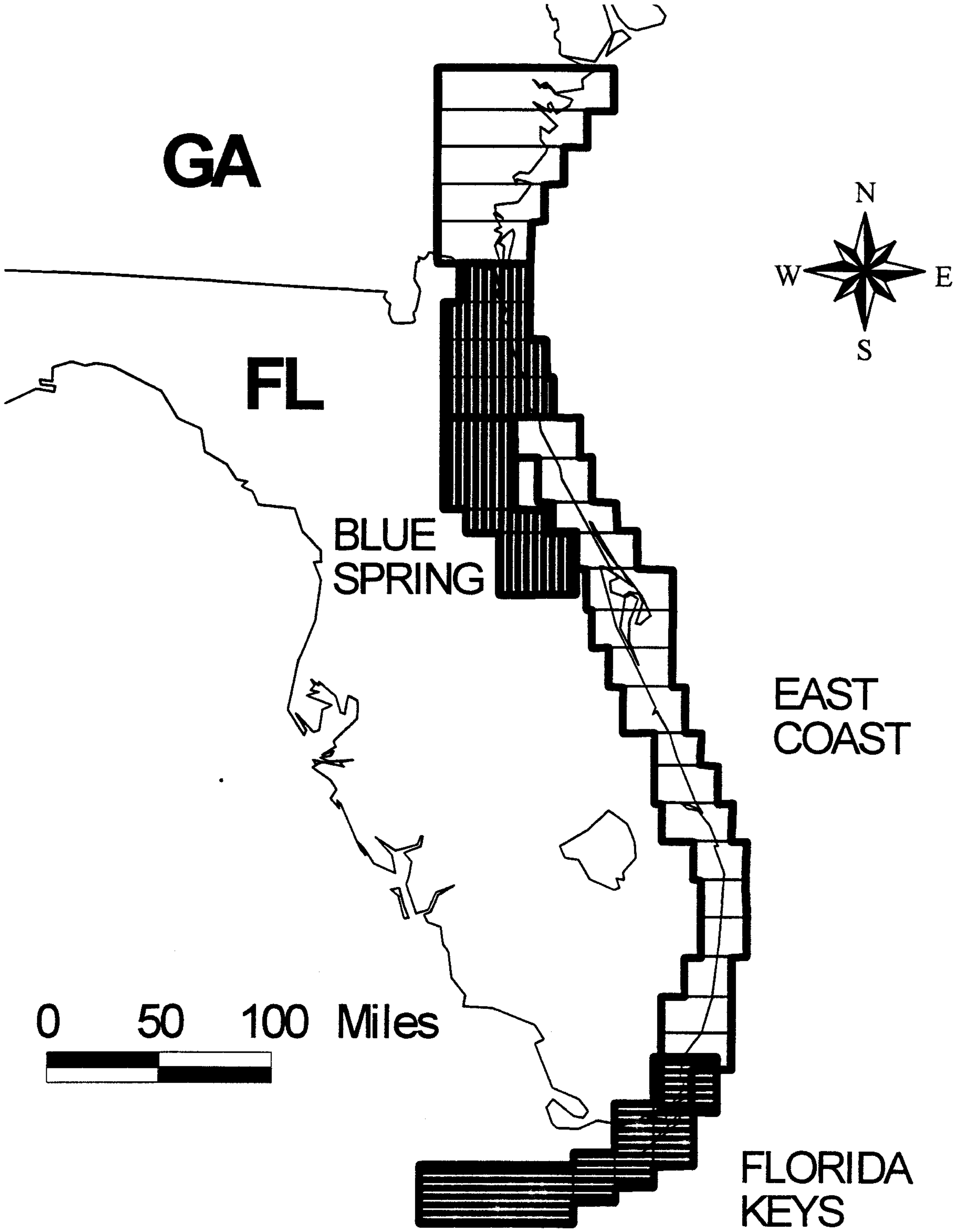

Figure 7. Latitude-longitude windows used to flag putative outliers in the PTT telemetry database during SAS data processing. Different sets of windows were used for East coast, Blue Spring, and Florida Keys manatees.

A total of 52,811 "guaranteed" locations for 61 manatees were obtained through Service Argos on 17,579 tag-days over the nine-year period represented in the PTT database (Table 5, Fig. 6). At least one "guaranteed" location for each deployed PTT was obtained on 93% of all tag-days pooled (Table 5). An average of 3.0 "guaranteed" locations per day were acquired for each manatee carrying a satellite-monitored transmitter. Locations were spread approximately equally across four 3-hr time periods representing the programmed duty cycles and the timing of satellite passes over Florida (Fig. 8).

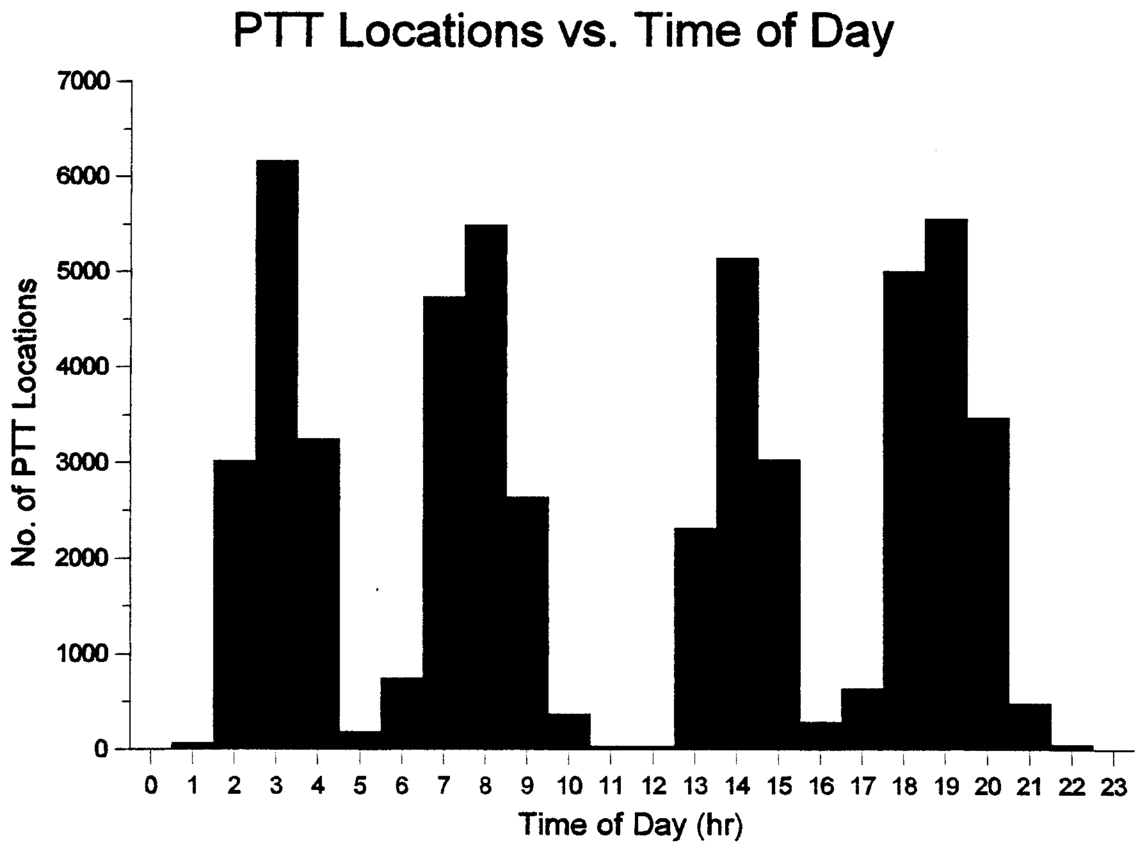

Figure 8. Number of satellite-determined manatee locations (n = 57,688) as a function of time of day along the Atlantic coast of Florida and Georgia from December 1986 to September 1995. Each time of day value includes the 60 minutes following the start of the hour (e.g., 11 refers to the period from 1100 - 1159 hr).

PRELIMINARY RESULTS AND DISCUSSION

Most of the work to date has focused on the development, quality control, and qualitative and quantitative descriptions of the radio-telemetry and associated databases (Deutsch et al. 1995, 1996). What follows are the results from some preliminary analyses of these data through September 1995 (see also Reid and O'Shea 1989, Sirenia Project 1993, Reid et al. 1995). The first section characterizes the annual movement patterns and migratory behavior of radio-tagged manatees along the Atlantic coast. Then site fidelity to warm-season home ranges and diel movement patterns are briefly discussed. Finally, a case study of the how the telemetry data have been applied to address issues of manatee management is presented.

Annual Movement Patterns

The annual patterns of movement were determined for 41 radio-tagged manatees; data were insufficient to ascertain patterns for the remaining study animals. These long-term movement patterns are described according to the occurrence (presence/absence) of seasonal migrations, the geographic regions encompassed by long-distance movements, the distance between winter and summer ranges, and the timing of seasonal movements in relation to temperature change.

Occurrence of Seasonal Migrations

At a gross level, manatee movement patterns could be categorized into two basic types, year-round residents and seasonal migrants. Year-round residents were defined as those animals remaining within the same 50-km stretch of coastline all year-long, as illustrated in Figure 9 for a subadult male in Brevard County. They usually moved to local power plant discharges during winter cold periods. Figure 10 shows the north-south movements of a typical seasonal migrant over the annual cycle. Migratory manatees exhibited the following general pattern of movement: they departed their warm-season range and travelled south upon the onset of cold fronts in late fall and early winter; overwintered in southeast Florida in the vicinity of power plant thermal discharges or in rivers, residential canals and bays; then migrated back north as air and water temperatures moderated during late winter and early spring. These observations are concordant with those obtained from photo-identification studies (Reid et al. 1991) and aerial surveys (e.g., Provancha and Provancha 1988, Weigle et al. 1987) along Florida's east coast. Travel between summer and winter ranges was typically direct and rapid, ranging from 20 to 50 km per day of travel. The southbound trip from Brevard County to southeast Florida (approximately 200-300 km) lasted a median of 10 days (range = 5 - 66 days, n = 34); this included a median of 6.5 days (range = 5 - 13 days, n = 22) of travelling plus brief stopovers along the way. Most migratory movements occurred in the relatively narrow Intracoastal Waterway (ICW), but occasionally manatees travelled close to shore in the ocean between inlets. Of the 41 manatees for which sufficient data on annual movements were available, 85% (n = 35) migrated seasonally and 15% (n = 6) remained resident in a given region year-round.

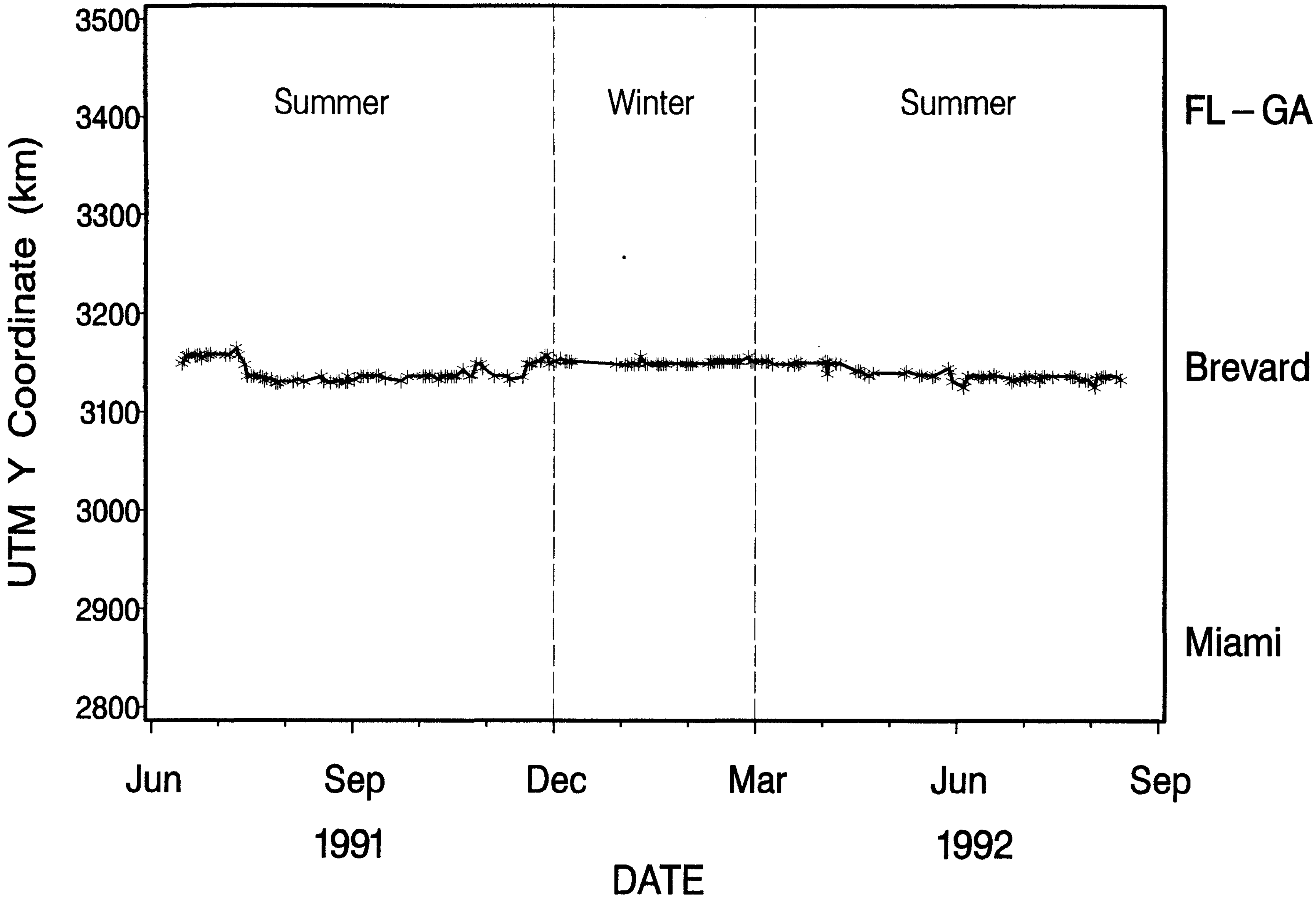

Figure 9. Annual latitudinal movements of subadult male TBC – 27 ("Mel"), a typical year – round resident of Brevard County.

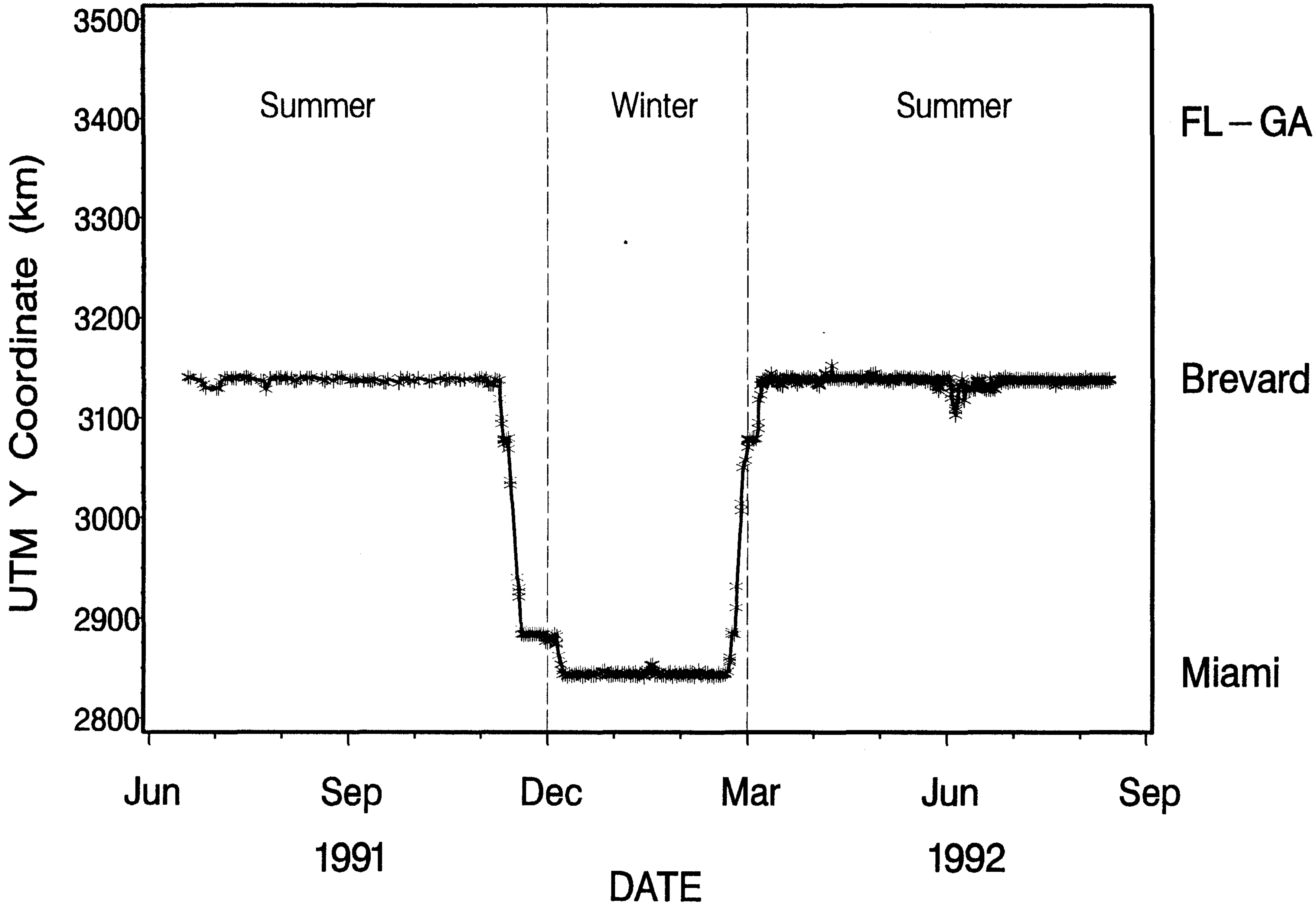

Figure 10. Annual latitudinal movements of adult female TBC – 24 ("Betty"), a typical seasonal migrant between central and southeast Florida.

Variation in Annual Movement Patterns: Geographic Region and Migratory Distance

Variation in annual movement patterns was more complex, however, than indicated by a simple migrant-resident dichotomy. There was considerable variation in the destinations of seasonal migrations, including four main types. The most common migration pattern, shown by 21 (60%) of the 35 migratory manatees with good tracking records, was from central Florida in summer to south Florida in winter (Fig. 11). Six (17%) manatees exhibited a similar pattern but shifted to the North, moving to southeast Georgia in the spring and summer months and overwintering in Brevard County (Fig. 11). Manatees showing these two migratory patterns were often simultaneously present in Brevard County during the spring and fall (see Fig. 11). Five (14%) study animals made short-distance migrations (50-100 km) within a given geographic region, while three others (9%) travelled the entire length of Florida's east coast and into Georgia, a straight-line distance of nearly 600 km (Fig. 12; see also Fig. 6 in Reid et al. 1995). These long-distance migrants often spent considerable time in Brevard County during spring or fall.

The latitudinal distance between "summer" (Apr. to Oct.) and winter (Dec. to Feb.) ranges was highly variable, ranging from 15 to 550 km (Fig. 13). The bimodal frequency distribution highlights two groups: (1) year-round residents and short-distance migrants (< 100 km), and (2) migrants that travelled about half the length of Florida's Atlantic coast (200-300 km). The median migratory distance for 26 wild-caught manatees was 250 km. This distance was similar for eight manatees rehabilitated in captivity as adults (median = 190 km), but three animals rehabilitated as calves (and released as subadults) showed little seasonal movement (median = 20 km). Body size and age could not account for the observed variation. Migration distance was not significantly correlated with body length among wild-caught adult females ($r_s = -0.09$, $P > 0.50$, $n = 18$; including rehabilitated adult females: $r_s = -0.04$, $P > 0.50$, $n = 24$). There was also no significant difference in migration distance between wild-caught adults ($n = 20$) and subadults ($n = 6$) (Wilcoxen two-sample test, $P > 0.50$).

The migratory movements of one of the study animals not included in the above analyses deserves special mention. TBC-42, known to the public as "Chessie," was a large adult male manatee that travelled over 2000 km (straight-line distance along coast) from Florida to Rhode Island, breaking scientific records for the most northerly location and for the longest migration of a West Indian manatee (Fig. 14) (Reid 1995). Fearing that he would succumb to cold stress from the approaching winter, the U.S. Fish and Wildlife Service captured Chessie on 1 October 1994 in the upper Chesapeake Bay, Virginia—where he had been sighted since late summer—and transported him to Florida on a U.S. Coast Guard C-130 aircraft. Chessie was radio-tagged and released in the Banana River, Brevard County and travelled to Port Everglades in southeast Florida, where he spent much of the winter. He returned to the Banana River by late February 1995 and reached the lower St. John's River by early May. All of these areas are heavily utilized by manatees, indicating that Chessie was probably quite familiar with important manatee habitats along the east coast of Florida. In mid-June 1995 he launched into his two-month-long northward journey, as revealed by Argos locations; he typically covered 40 to 50 km per day, rarely lingering more than one day in a given area (Fig. 14). Chessie briefly entered the

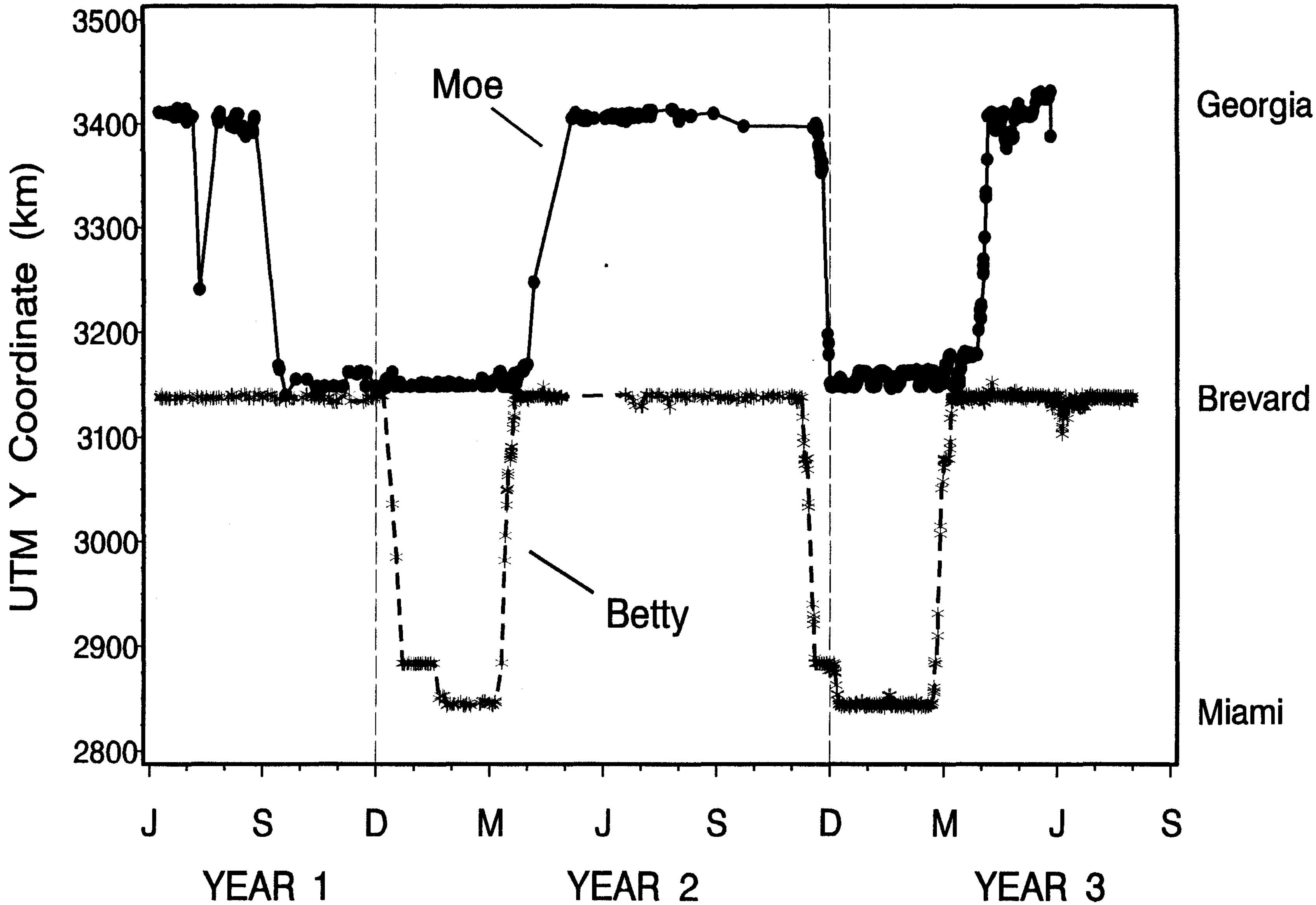

Figure 11. Examples of two types of seasonal migratory patterns: (1) Southeast Georgia to central Florida (TBC – 06, "Moe"), and (2) central Florida to southeast Florida (TBC – 24, "Betty").

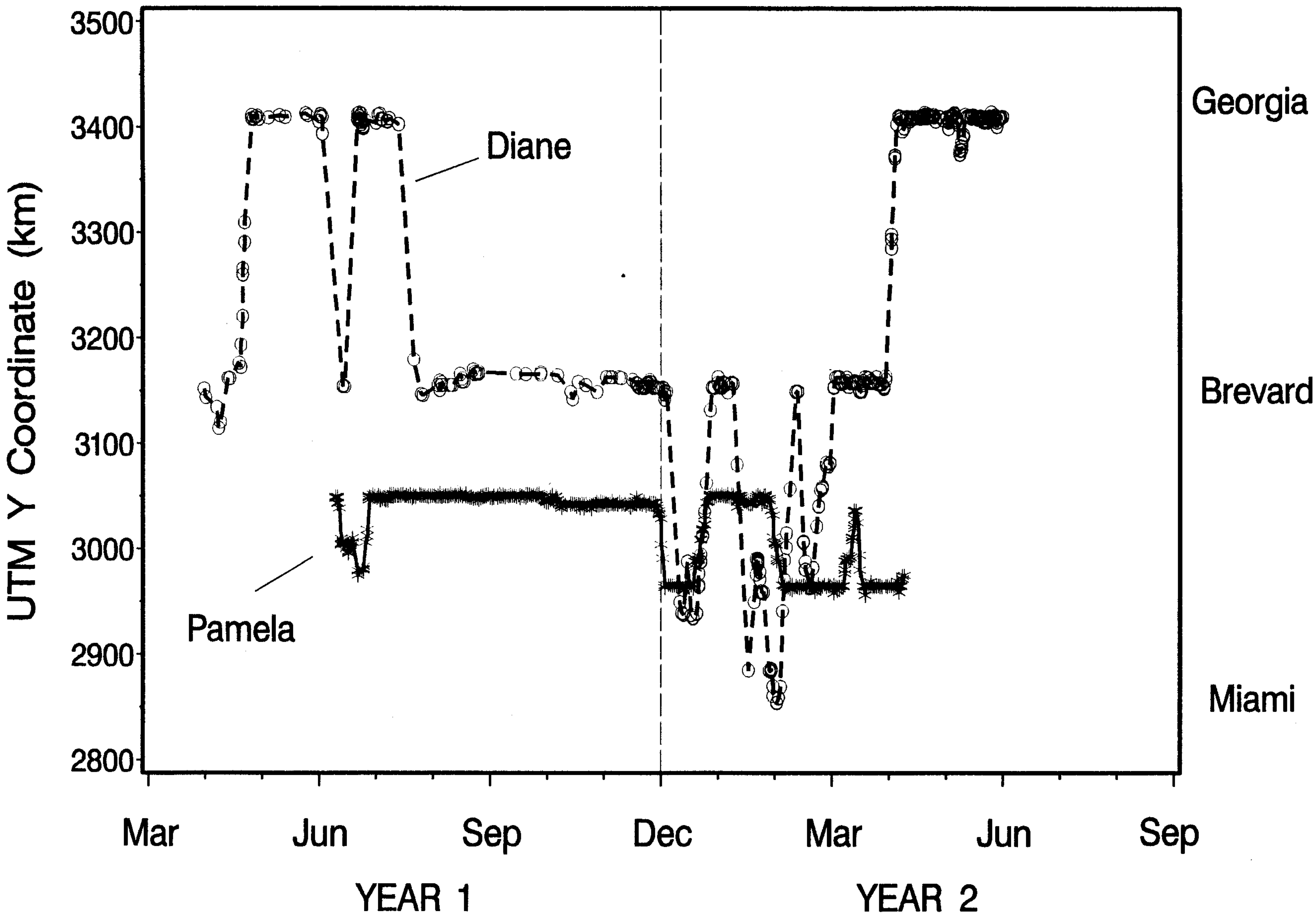

Figure 12. Examples of two types of seasonal migratory patterns: (1) Southeast Georgia to southeast Florida (TNC-01, "Diane"), and (2) short-distance migration within a region (TBC-37, "Pamela").

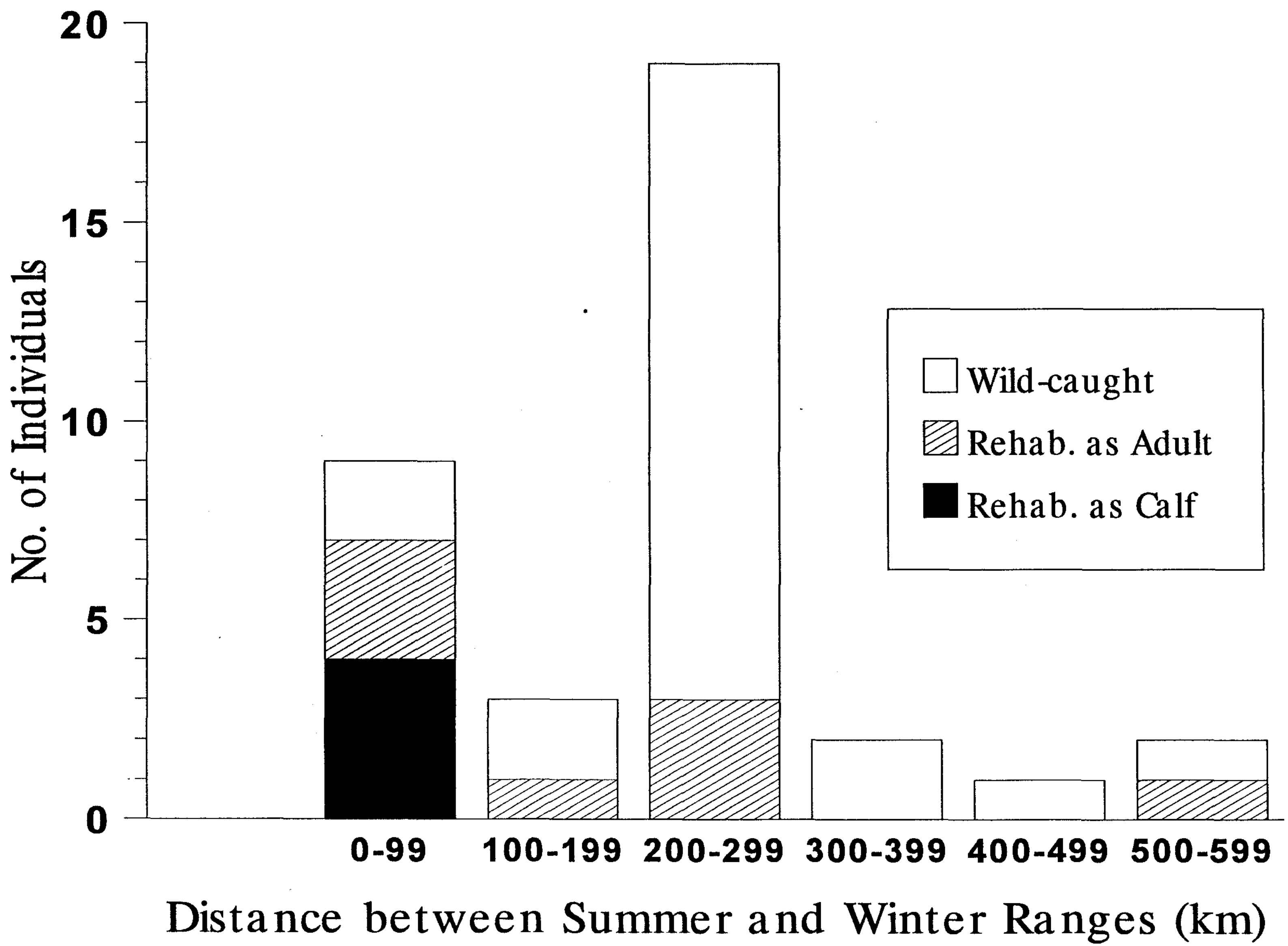

Figure 13. Frequency distribution of latitudinal distance between summer and winter home ranges for radio-tagged manatees as a function of rehabilitation status (Kruskal-Wallis test, $P < 0.05$).

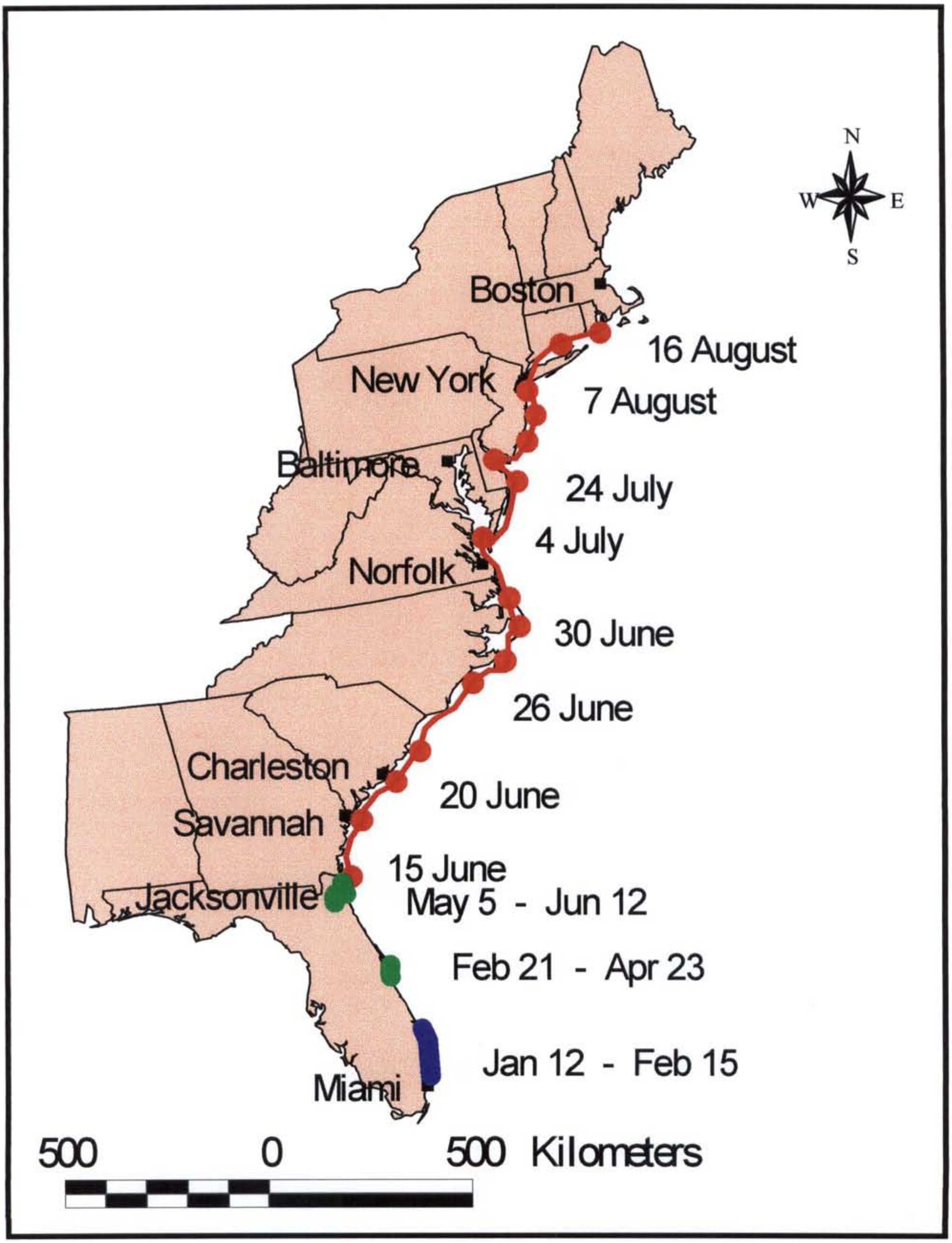

Figure 14. Northward migration of adult male TBC-42 ("Chessie") along the Atlantic seaboard from Florida to Rhode Island in 1995. He returned to Jacksonville, Florida by mid-November. Only a subset of PTT locations and dates are shown here.

lower Chesapeake Bay in early July 1995 and continued north through New York City and into Long Island Sound by early August. He finally reversed his northward movement on 16 August at Pt. Judith, Rhode Island, where he encountered water temperatures of 19-20 °C, the coldest of the trip. The tag detached about one week later off New Haven, Connecticut. This continuous tracking bout lasted 222 days from retagging in Ft. Lauderdale in January. Chessie's journey from north Florida to Rhode Island took 64 days and ranged along the coasts of 11 states. Although the duration, distance and destination of this migratory move were certainly extreme compared to the rest of the Florida manatee population, Chessie's activity and habitat use appeared typical for a manatee in more temperate waters, such as those found in north Florida and Georgia. He chose salt marsh and estuarine habitats for resting and feeding, and travelled primarily in the ICW or in shallow lagoons and sounds inshore of barrier islands. Furthermore, manatees are sighted regularly and with increasing frequency during the warm months along the southeast coast of the United States, including Virginia and the Carolinas (Rathbun et al. 1982, Schwartz 1995), indicating that Chessie is not an isolated wanderer. Public sighting reports allowed us to document Chessie's return trip south to Jacksonville, Florida by mid-November. This manatee Olympian has taught us what manatees are capable of achieving: a round-trip of well over 3500 km between north Florida and New England in five months; and an average rate of travel of 50 km/day sustained for 3 weeks over about 1000 km of coastline from southern Georgia to the Chesapeake Bay.

Timing of Seasonal Migrations

The timing of the fall migration and its relationship to temperature change was examined for radio-tagged manatees in Brevard County waters. Visual inspection of graphs showing changes in latitudinal movements and water temperature (in Banana Creek) over time strongly suggests that manatees initiated migratory moves in response to the passage of strong cold fronts in late fall or early winter (Fig. 15). There appears to be variation among manatees in the threshold temperature at which this response occurs, however. The mean date at which manatees initiated their southward migration from their warm-season range was 8 December, but there was considerable variability in departure date among individuals (early November to late January) and across years. Some of the individual variation may be related to differences in "cold-tolerance" and some to differential use of the Brevard County power plant thermal effluents. Inter-annual variation in the onset of cold weather apparently accounted for some of the variation in migratory timing. Mean departure date from Brevard County was positively correlated with the first date at which mean daily water temperature dropped below 17 °C ($r = 0.76$, $n = 7$ years) (Fig. 16). Note that data for some of the same individuals were included in multiple years, breaking the assumption of statistical independence required for a hypothesis test of correlation; a repeated measures type of analysis will be necessary. These findings are generally consistent with current knowledge of manatee response to cold temperatures, but they suggest that individual thermal tolerances may be greater than that indicated by previous experimental studies on the lower limits of thermoneutrality (Irvine 1983).

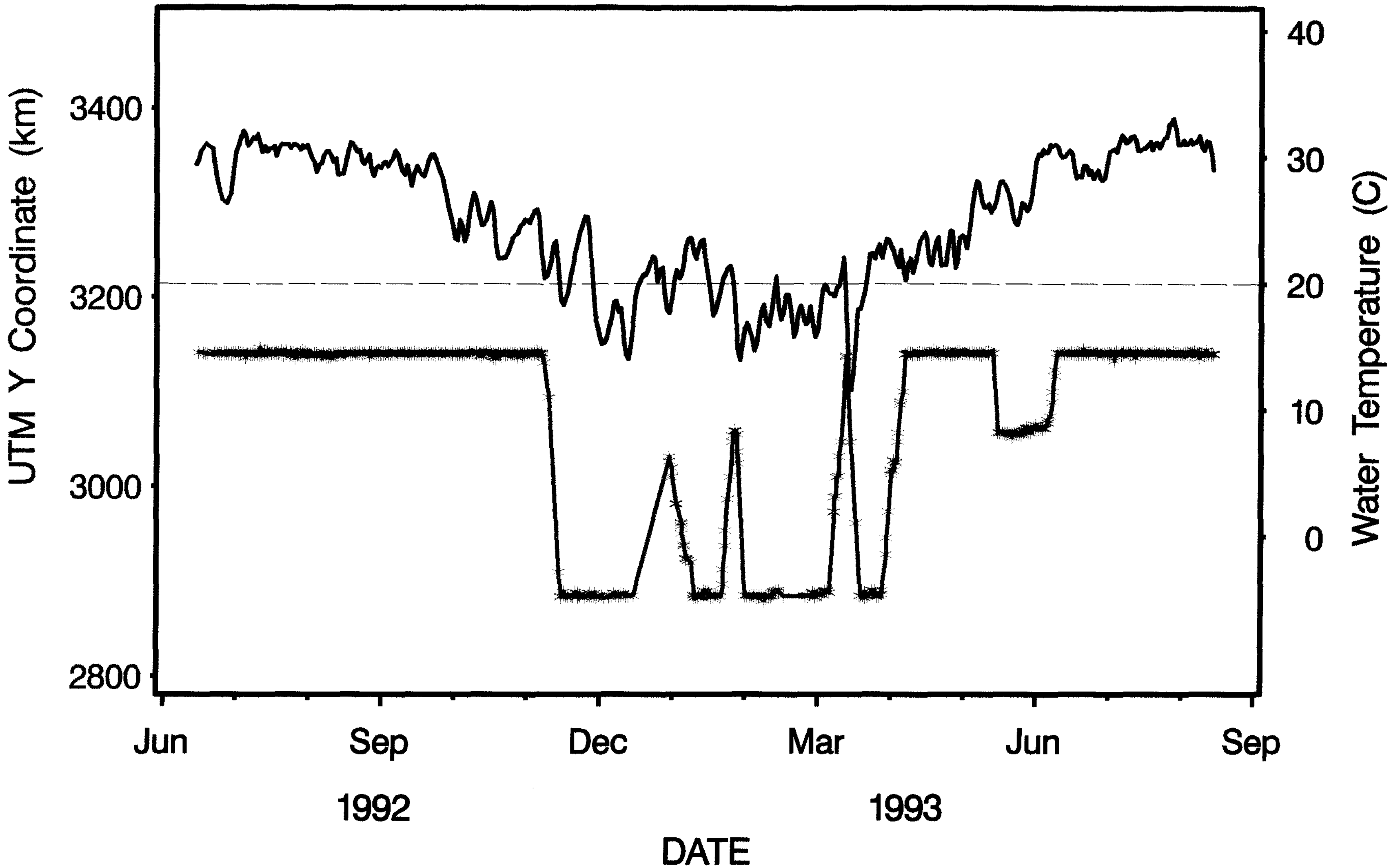

Figure 15. Latitudinal movements of adult female TBC–09 ("C–cow") in relation to mean daily water temperature in the Banana Creek, Brevard County. C–cow spent the warm months in Brevard and overwintered in Fort Lauderdale; she attempted three return migrations to Brevard during the 1992–93 winter, only to be turned back by temperature drops. The horizontal dashed line indicates 20 C.

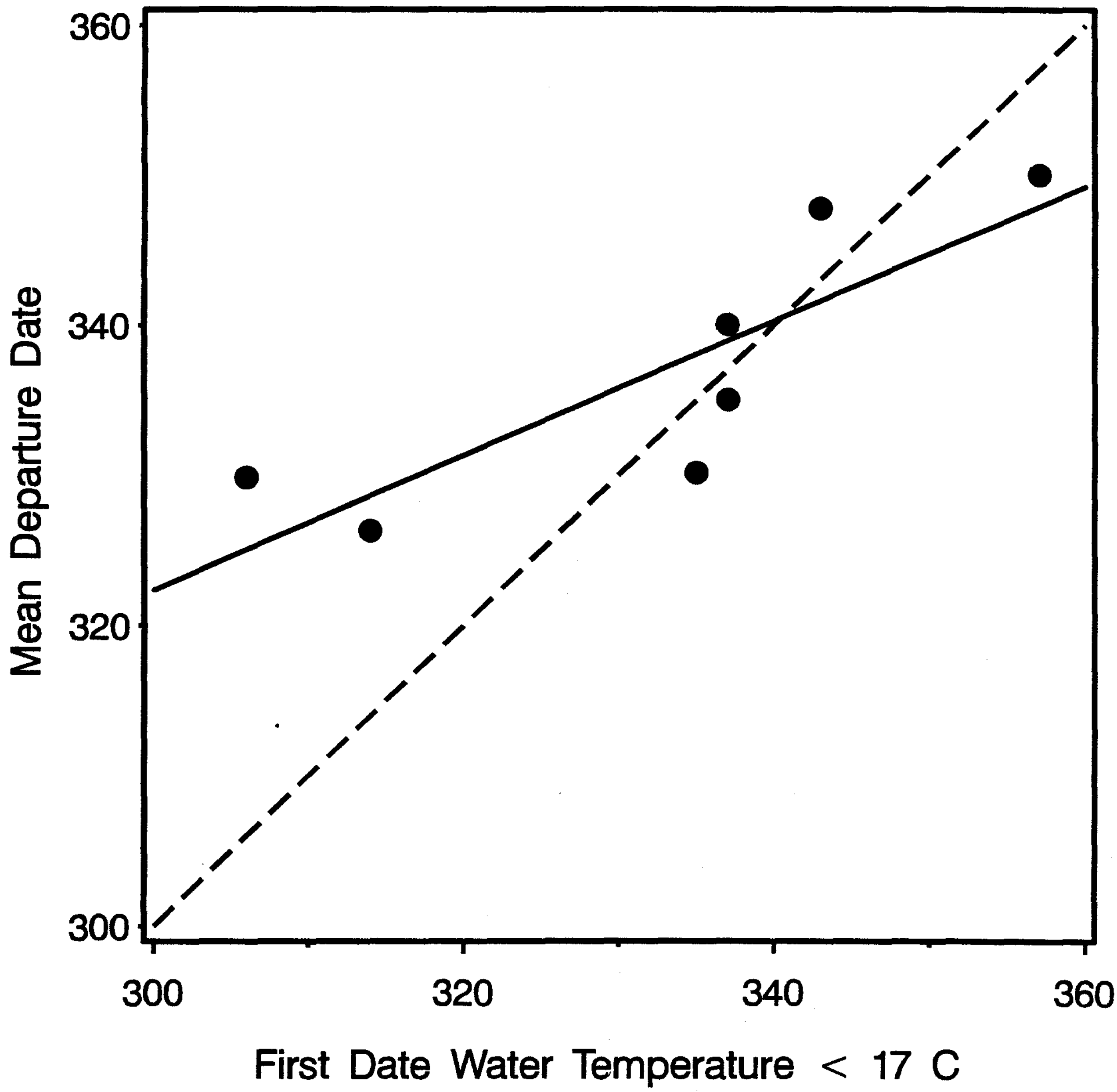

Figure 16. The mean julian date at which migratory tagged manatees departed Brevard County in fall as a function of the first julian date that mean daily water temperature dropped below 17 C. Means for seven years are plotted (n=3–7 individuals per year). Temperatures were recorded in Banana Creek, Brevard County. The dashed line indicates equality between mean departure date and the date on which the 17 C temperature threshold was crossed.

Site Fidelity to Warm-season Range

Long-term field studies of recognizable individuals have documented strong site fidelity to winter aggregation sites in a number of regions (O'Shea and Langtimm 1995) but there has been relatively little known about the occurrence of site fidelity to summer ranges (Reid et al. 1991). Some radio-tagged manatees showed remarkable consistency in the extent, timing and destination of their seasonal movements from year to year, as exemplified in a five-year tracking record for TBC-24, Betty (Fig. 17). This adult female occupied three areas along the east coast: the Banana River, Brevard County from early spring through late autumn; and two sites, Port Everglades and Coral Gables, in south Florida during the winter period. I considered a manatee to show regional site fidelity to a warm-season home range if it returned to the same 25-km section of the coast in two or more years. Of 18 individuals with at least two years of summer tracking data, 14 (78%) were site faithful from year to year by these criteria. Three of the other four manatees were faithful to two widely separated core ranges in summer. Many manatees also made brief trips outside of their principal home ranges during the warm months.

Although this has not yet been thoroughly investigated, site fidelity to a warm-season home range was also apparent at a much finer spatial scale. Figure 18 illustrates this interannual consistency in spatial use pattern for TBC-24 in the mid-Banana River from April through October. Note how her movements were restricted to a relatively small portion of this water body. This area provided excellent habitat for manatees: abundant seagrass flats on the east side; residential canals for resting on the west side; and a reliable freshwater source (Cape Canaveral sewage discharge) which served as a major manatee attractant. The larger area indicated by locations in 1992 compared to the previous two years may have been related to Betty's weaning of her calf during that summer (Fig. 18). It is confounded, however, by the fact that the first two years relied principally on VHF sightings whereas most locational data were acquired via satellite in 1992.

Diel Movement Patterns

The spatial distribution of radio-tagged manatees (n = 8) overwintering in northern Biscayne Bay was examined as a function of time of day. A clear diel pattern was revealed: manatees spent the afternoon in the Little River and nearby canals, moved downriver and into the bay in the early evening, spent the night and the morning in the bay up to 3 km from the mouth of the Little River, and returned to the nearshore and inland areas in the late morning (Fig. 19). Field observations by Project staff substantiated this pattern and indicated that manatees mostly rested or socialized in the Little River (K. Curtin, pers. comm.). At night the manatees presumably foraged on the extensive beds of seagrass (mostly *Halodule wrightii*) or algae in the middle of the bay. Bengtson (1981) described a similar diel pattern of movement between Blue Spring run and foraging areas in the St. John's River during the winter months, which he attributed to diurnal fluctuations in air and water temperatures. Likewise, manatees overwintering at the warm-water springs of Crystal and Homosassa Rivers generally move downriver to foraging areas in the late afternoon or at dusk and return to the springs by dawn

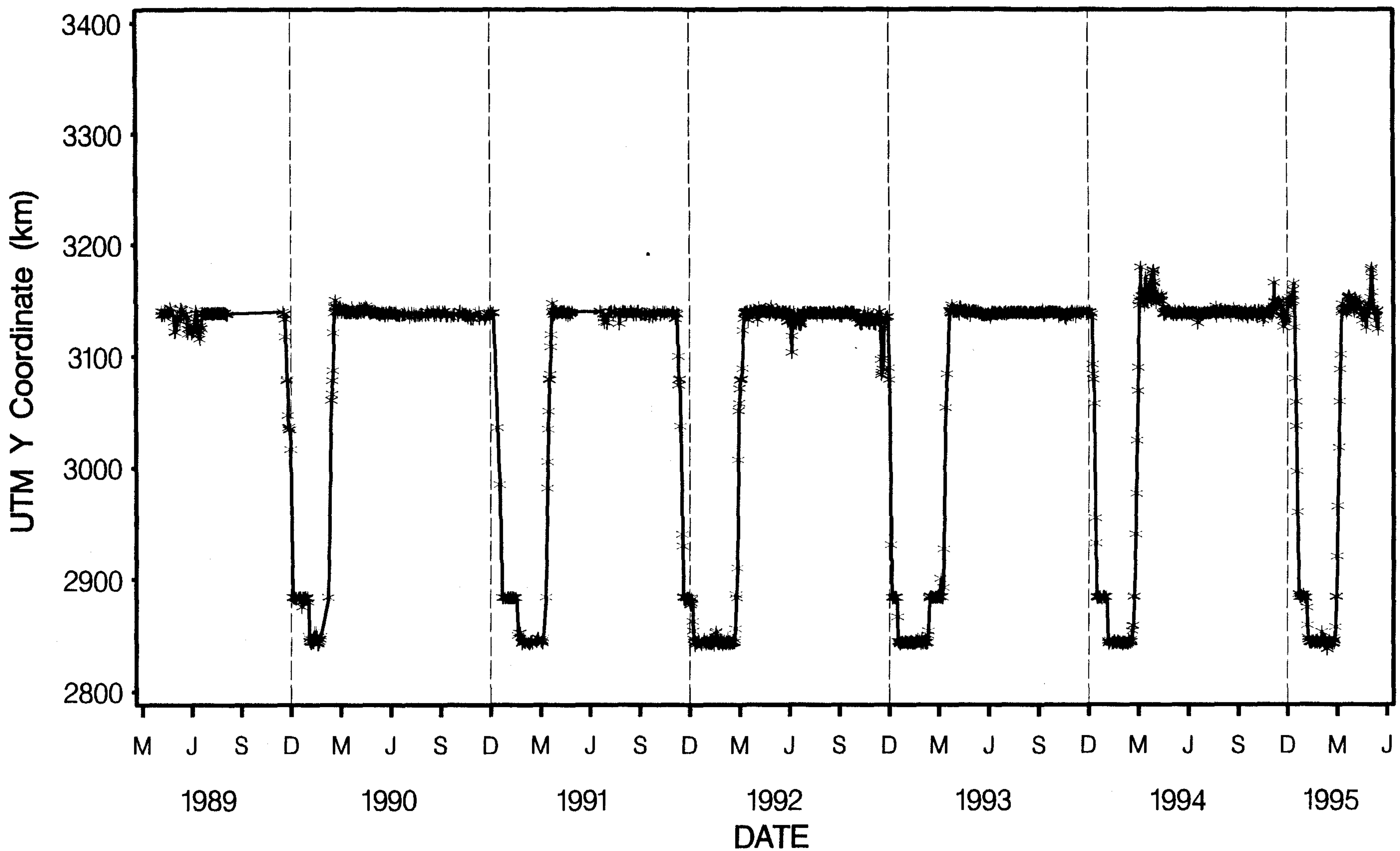

Figure 17. Year–to–year consistency in annual movement patterns, as exemplified by the latitudinal movements of adult female TBC–24 ("Betty") over a six–year period. She summered in the Banana River, Brevard County and overwintered in Port Everglades and Coral Gables. The vertical dashed lines represent the approximate start of the winter season (1 December). One location per day is plotted.

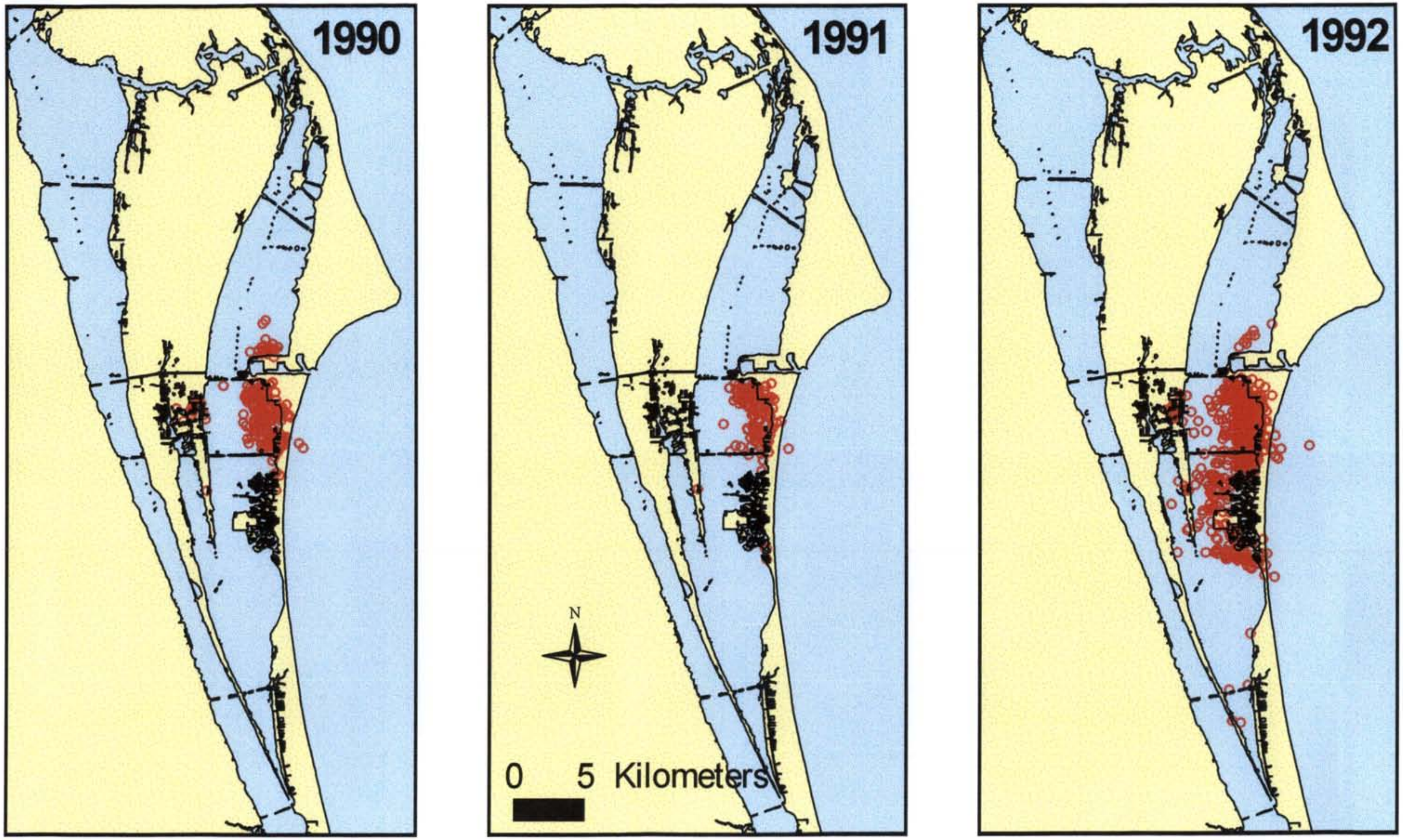

Figure 18. Site fidelity to warm-season home range, as shown by the distribution of PTT and VHF locations in three consecutive years for adult female TBC-24 ("Betty") in the mid-Banana River, Brevard County, Florida. Only PTT location classes of 2 and 3, and VHF visual sightings are plotted.

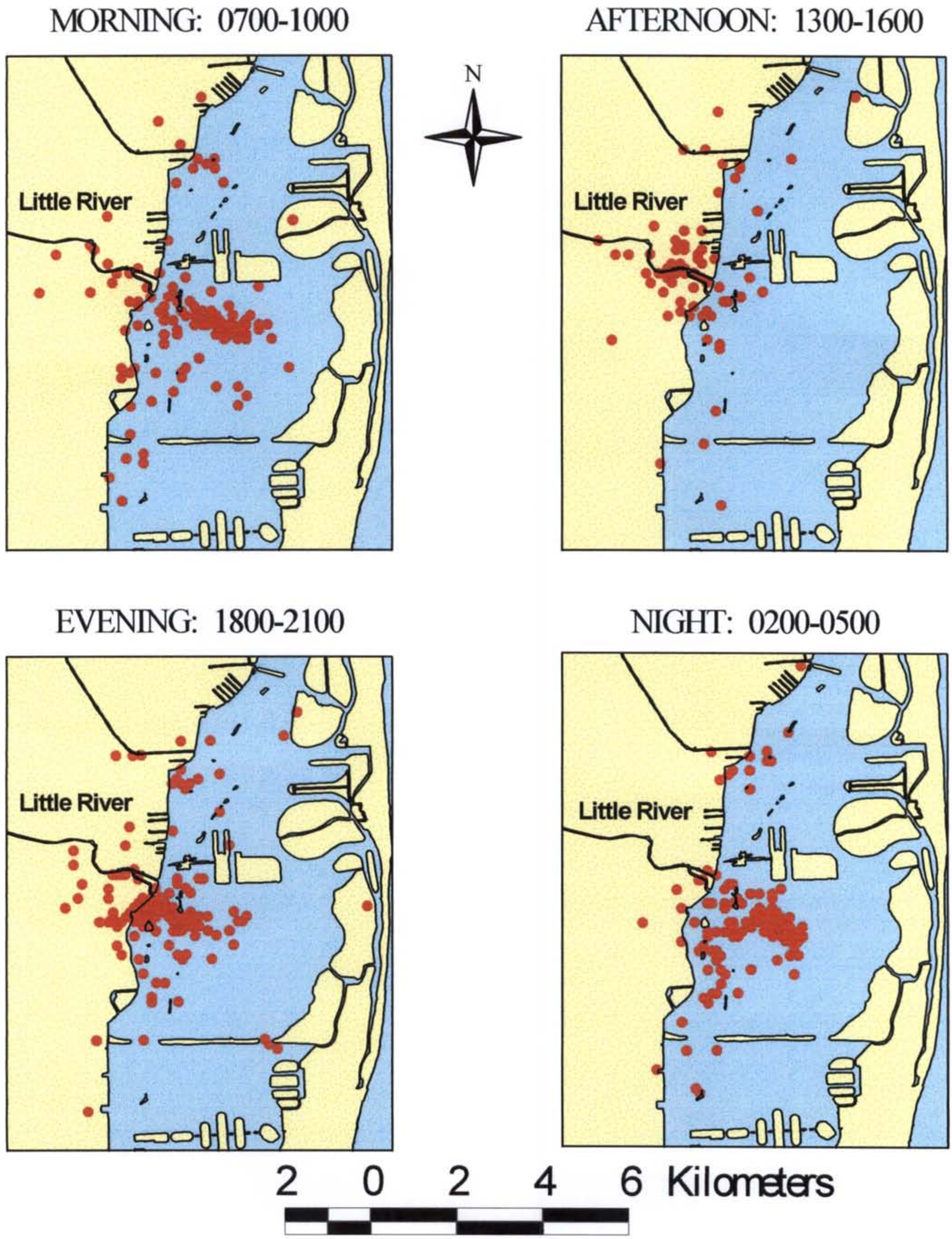

Figure 19. Winter distribution (Dec. - Feb.) of satellite-determined locations for eight tagged manatees in north Biscayne Bay, Florida between 1986 and 1995 as a function of time of day (EST). Location classes 2 and 3 only (n = 487).

(Rathbun et al. 1990). This type of diel cycle also appeared to occur in Brevard County during the summer months (S. Tyson, pers. comm.), indicating that factors other than temperature, such as motor vessel traffic (Reynolds 1981) and sea state, may also be responsible for such patterns.

Management Applications

The radio-telemetry study has yielded data on seasonal variation in manatee movements and high-use areas along the Atlantic coast which have been valuable in the development of measures by federal, state and county managers charged with recovering the population and protecting its habitat. Along with aerial survey and other sources of data, for example, the telemetry information was used to help justify the designation of manatee protected areas in the upper Banana River and in the north fork of the Sebastian River. Florida manatees have demonstrated flexibility and opportunism in their ability to adapt to human-modified environments and have taken advantage of manatee sanctuaries shielded from human disturbances (O'Shea 1988).

A case study of how spatial data from tagged manatees have been analyzed to assist managers in rule-making decisions is summarized here, with the text of the report given in Appendix 7. An area south of the Minuteman Causeway, Cocoa Beach had been designated a watersports zone (e.g., for water skiing) prior to 1991 and was changed at that time to a slow speed zone for motor vessels because of consistent use by manatees in the area, as determined from aerial surveys (L. Ruhana, pers. comm.). Earlier this year the Brevard County Commission was considering a recommendation to reopen this area for watersports use. The Florida Department of Environmental Protection's (FDEP) Bureau of Protected Species Management (BPSM) requested our assistance in evaluating recent manatee use of the area encompassing Cocoa Beach and the Thousand Islands, with special emphasis on the proposed watersports zone (see map in Appendix 7). Special protocols were developed to integrate the spatial analysis functions of ArcView with the data manipulation and statistical analysis capabilities of SAS.

Based on PTT data between 1992 and 1995, I found that 16 (64%) of the 25 tagged manatees that used the Banana River were located at least once in the Cocoa Beach / Thousand Islands area. Half of these individuals were located there on at least 20 days (maximum = 167 days). Pronounced seasonal variation in manatee use was evident, with greatest use during the spring/early summer and fall. These time periods correspond approximately to the end of the spring migration and the start of the fall migration, respectively, suggesting that Cocoa Beach waters may be used as a "staging" area for migrant manatees moving into and out of the Banana River. The area was rarely used during the winter months. The small size of the proposed watersports zone made it more difficult to formulate firm conclusions, but it showed the same seasonal use pattern as for the larger Cocoa area. This zone did not appear to be a hotspot of tagged manatee use, but it is likely that manatees passed through or near it when travelling between important foraging and resting areas to the north and south. The residential canals and other sheltered waterways in the Ten Thousand Islands area were used by tagged manatees for resting; they often moved offshore to feed on seagrass beds, a favorite foraging ground being located along the southern edge of the Cocoa Beach area. The telemetry data could not be used to directly assess whether manatees were swimming through the small zone of interest, because the radio-tag is usually pulled underwater when a manatee is travelling, resulting in few high-quality locations. Potential travel corridors can be modelled using cost-path analyses in a raster-based GIS (Weigle and Flamm 1995), but the urgency of the request did not permit more sophisticated analyses.

SUMMARY

The principal objective of this work was to analyze ten years of data on the seasonal and short-term movements and spatial use patterns of Florida manatees along the Atlantic coast. Locational data were collected using conventional, field-monitored VHF radio-transmitters and satellite-monitored UHF platform transmitter terminals (PTTs). Major tasks were identified and prioritized, and considerable progress was made in updating, error-checking and characterizing several telemetry databases, with emphasis on improving quality control. A new database on the attributes of individual tagged manatees was created and has proved useful in analyzing migratory patterns as a function of sex, age class and rehabilitation status. Database quality control procedures were improved through modifications to SAS error-scanning programs, and databases were verified through manual proofing, as necessary. Problems and inconsistencies in the databases were identified and resolved. For example, manatee activity codes were revised and standardized across observers, and this may prove useful in understanding habitat use. This phase of the analysis dealing with the development and quality control of spatial databases on manatee distribution and movements is nearing completion. The VHF telemetry, tagged manatee identity, and tagging history databases now encompass the period from May 1986 through May 1996. The PTT telemetry database currently covers the period from December 1986 through September 1995.

The Sirenia Project radio-tagged and tracked 83 manatees along the Atlantic coast, from the Florida Keys to southeast Georgia, between May 1986 and May 1996. Over half (58%) of these subjects were tagged in the Indian River lagoon system of Brevard County in central Florida. Between 18 and 26 individuals were tracked during each full year of the study (1987-1995). Most study animals were female (61%), adult (80%), and free-ranging (71%) at tagging. Lengths ranged from 200 cm (for a dependent calf) to 350 cm. Most (58%) of the 24 rehabilitated manatees had been held in aquaria for less than one year (range, 6 days to 7.1 years) prior to their release and four were born in captivity. Tagged manatees were tracked for a median duration of 7 months (range, 2 days to 6.8 years). Despite frequent tag detachments and limited PTT battery life (about 8 months), the duration of continuous tracking bouts lasted up to 2.7 years. Such long tracking durations were made possible through replacing or reattaching radio-tags, typically without recapturing the animal. About two-thirds of the study animals were tracked over multiple tag deployments (median = 3.0 bouts per animal, maximum = 39). They carried radio-tags for a total of 30,812 days (33.3% VHF tags, 66.7% PTT tags), equivalent to 84.4 animal-years, yielding over 11,000 VHF locations (on 28% of total tag-days) and over 50,000 PTT locations (on 93% of PTT tag-days). On average, 3 good quality (LC1-3) locations per day were provided by Service Argos for manatees carrying satellite-monitored transmitters.

Analysis of manatee movement and spatial use patterns is in its initial stages. Preliminary findings on annual movement patterns include the following: (1) About 90% of manatees tagged in the wild made seasonal migrations, typically between south Florida in winter and central Florida during the warm season, while the remainder were resident year-round in a

given region. Brevard County, especially the Banana River, was the most heavily utilized area during the non-winter months. (2) Individuals varied considerably in the extent and destinations of seasonal movements. Distance between summer and winter ranges (median = 250 km) did not vary significantly with age class or adult body size. One adult male made a spectacular journey from north Florida to Rhode Island over a two-month period in the summer of 1995, breaking records for the most northerly documented location and the longest migration for a West Indian manatee. (3) Migratory travel between summer and winter ranges was usually direct and rapid (up to 50 km/day), and was prompted by changing water temperatures. There was substantial variation among individuals and years in the date that fall migratory movements were initiated; the hypothesis that individuals respond at different temperature thresholds needs further investigation. (4) Most individuals exhibited strong site fidelity to warm-season ranges across years. Cursory analysis of within-season movements revealed a clear diel movement pattern for manatees overwintering in north Biscayne Bay; they utilized the inshore canals and rivers during the afternoon and moved offshore in the evening to forage on seagrass beds through the night and early morning hours. The information provided by this long-term radio-telemetry study has been and will continue to be valuable to federal, state and county managers who must make regulatory and permit decisions to protect this endangered aquatic mammal and its habitat from increasing human encroachment in Florida's coastal zone.

ACKNOWLEDGEMENTS

This research project has truly been a collaborative effort among many researchers, both in terms of data collection in the field and spatial database development in the laboratory. The Atlantic coast radio-telemetry study was initiated by Dr. Tom O'Shea, Jim Reid and Bob Bonde and continued under the leadership of Dr. Lynn Lefebvre. A number of Sirenia Project staff members contributed greatly to the development of the telemetry databases described in this report, including Bob Bonde, Susan Butler, Dean Easton, Jim Henderson, Howard Kochman and Jim Reid. Howard, in particular, deserves credit for most of the SAS programming that was responsible for database creation and error-scanning. Dean and Susan have tackled numerous challenges presented by the VHF telemetry database with unflagging devotion, thorough scrutiny and good humor. Without all of their concerted efforts, little progress would have been made in updating, processing and analyzing these large, long-term datasets. I thank Dean Easton, Michele Klaips, and Christina Lucas for assistance with figure preparation. I am grateful to Dr. Lynn Lefebvre for her support and persistence in keeping my Research Work Order funded throughout this last trying fiscal year. I also thank Dr. H. Franklin Percival and Barbara Fesler of the Florida Cooperative Fish and Wildlife Research Unit (National Biological Service and University of Florida) for their continued assistance and administrative support of this RWO. Funding for this work was provided by the Sirenia Project (NBS), U. S. Fish and Wildlife Service, and Save the Manatee Club (SMC). I am very grateful to Judith Vallee and the Board of Directors of SMC for their willingness to provide funding for this work at short notice.

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REPORT APPENDICES

Appendix 1a. Radio-tagged manatee identity database for the Atlantic coast of Florida and Georgia, from May 1986 through May 1996. SAS database name = tagmanid.sd2. N = 83 individuals.

Manatee ID	Name	Sex	Captive?	Date of Capture	Date of Release	Age Class at Capture	Age Class at Release	Length (cm) at Capture	Length (cm) at Release	No. Days Tracked	% Tracking Period	Months in Captivity
TBC-01	DIXIE	F	N	08MAY86	08MAY86	AD	AD	310	310	333	43	0.0
TBC-02	TRIXIE	F	N	08MAY86	08MAY86	AD	AD	270	270	41	100	0.0
TBC-03	MOON	F	N	30SEP86	30SEP86	AD	AD	277	277	1740	64	0.0
TBC-04	ECLIPSE	F	N	03OCT86	03OCT86	SU	SU	260	260	248	97	0.0
TBC-05	GYRO	F	N	13NOV86	13NOV86	AD	AD	267	267	319	58	0.0
TBC-06	MOE	M	N	20APR87	20APR87	SU	SU	260	260	852	64	0.0
TBC-07	BILL	M	N	21APR87	21APR87	AD	AD	270	270	65	100	0.0
TBC-08	ANGELA	F	N	23APR87	23APR87	AD	AD	325	325	53	100	0.0
TBC-09	C-COW	F	N	16JUN87	16JUN87	AD	AD	305	305	2478	83	0.0
TBC-10	FRAN	F	N	16NOV87	16NOV87	AD	AD	310	310	66	100	0.0
TBC-11	GLORIA	F	N	16NOV87	16NOV87	AD	AD	300	300	58	100	0.0
TBC-12	HEIKE	F	N	17NOV87	17NOV87	AD	AD	295	295	59	100	0.0
TBC-13	IRENE	F	N	17NOV87	17NOV87	SU	SU	260	260	234	100	0.0
TBC-14	JEROME	M	N	17NOV87	17NOV87	AD	AD	275	275	132	100	0.0
TBC-15	KAREN	F	N	18NOV87	18NOV87	AD	AD	280	280	281	30	0.0
TBC-16	LARRY	M	N	18NOV87	18NOV87	AD	AD	285	285	4	100	0.0
TBC-17	MADONNA	F	N	18NOV87	18NOV87	AD	AD	350	350	37	100	0.0
TBC-18	LEROY	M	N	30MAR88	30MAR88	AD	AD	280	280	96	24	0.0
TBC-19	SHARON	F	N	21APR88	21APR88	AD	AD	315	315	10	100	0.0
TBC-20	RUTH	F	N	21APR88	21APR88	AD	AD	270	270	671	73	0.0
TBC-21	WILLIE	M	N	22APR88	22APR88	AD	AD	280	280	161	24	0.0
TBC-22	MAGOO	M	Y	28JAN83	07JUN88	OR	AD	185	248	316	100	64.3
TBC-23	HILLARY	F	Y	04FEB88	07JUN88	AD	AD	268	273	893	34	4.1
TBC-24	BETTY	F	N	05APR89	05APR89	AD	AD	285	285	2059	92	0.0
TBC-25	D-COW	M	N	11APR89	11APR89	CA	CA	225	225	563	96	0.0
TBC-26	PEEWEE	F	N	16NOV89	16NOV89	AD	AD	270	270	1115	63	0.0
TBC-27	MEL	M	Y	02JAN88	02MAY90	OR	SU	203	240	622	88	28.0
TBC-28	LIBERTY	F	Y	04JUL88	02MAY90	SU	SU	229	235	157	100	21.9
TBC-29	CASEY	M	Y	23JUL90	21AUG90	CA	CA	210	210	431	88	1.0

Manatee ID	Name	Sex	Captive?	Date of Capture	Date of Release	Age Class at Capture	Age Class at Release	Length (cm) at Capture	Length (cm) at Release	No. Days Tracked	% Tracking Period	Months in Captivity
TBC-30	MARIA	F	N	30OCT90	30OCT90	AD	AD	280	280	119	100	0.0
TBC-31	FREDDIE	F	N	31OCT90	31OCT90	AD	AD	300	300	497	91	0.0
TBC-32	TOMASINA	F	N	22MAY91	22MAY91	AD	AD	~335	~335	225	19	0.0
TBC-33	ERNIE	M	Y	13MAY84	06JUN91	OR	AD	211	280	72	100	84.8
TBC-34	MILEY	M	Y	20NOV90	15JUL91	OR	SU	201	219	331	100	7.8
TBC-35	E-COW	F	N	05MAY92	05MAY92	CA	CA	230	230	225	76	0.0
TBC-36	SUNSHINE	F	N	15MAY92	15MAY92	AD	AD	~260	~260	539	82	0.0
TBC-37	PAMELA	F	Y	03SEP91	28MAY92	AD	AD	267	263	316	100	8.8
TBC-38	ADAIR	F	Y	09JUL86	28MAY92	SU	AD	229	288	302	22	70.6
TBC-39	LYDIA	F	Y	19JUL91	28MAY92	CB	CA	.	200	207	90	10.3
TBC-40	DANISE	F	Y	26SEP93	08JUN94	AD	AD	280	280	3	100	8.4
TBC-41	SCOTT	M	Y	06MAR94	09AUG94	AD	AD	271	274	160	100	5.1
TBC-42	CHESSIE	M	Y	01OCT94	07OCT94	AD	AD	310	315	333	55	0.2
TBC-43	ROBBIE	M	N	21APR95	21APR95	CA	CA	240	240	83	100	0.0
TBC-44	MOOSE	M	Y	01JUL91	01JUN95	OR	AD	141	284	182	100	47.0
TBC-45	HARVEY	M	Y	28AUG90	25AUG95	CB	AD	.	275	175	100	59.9
TBC-46	FOSTER	M	Y	19MAR93	25AUG95	CB	SU	122	255	127	100	29.2
TBC-47	INDY	M	Y	29APR92	25AUG95	CB	SU	117	268	77	100	39.9
TFK-01	MANNY	F	Y	15SEP93	21SEP93	AD	AD	295	295	216	96	0.2
TFK-02	STAN	M	N	19OCT93	19OCT93	AD	AD	~280	~280	164	76	0.0
TFK-03	OLLIE	M	N	19OCT93	19OCT93	AD	AD	~280	~280	119	100	0.0
TFP-01	HUTCH	M	Y	28DEC89	10APR90	AD	AD	302	305	11	100	3.4
TFP-02	ROSS	M	Y	31JUL90	07NOV90	AD	AD	288	295	1190	82	3.3
TFP-03	NATALIE	F	Y	04APR91	24JUL91	AD	AD	310	310	395	34	3.6
TFP-04	SOPHIA	F	N	26JUL91	26JUL91	AD	AD	~330	~330	460	27	0.0
TFP-05	LANI	F	N	10AUG91	10AUG91	AD	AD	~335	~335	307	53	0.0
TFP-06	VANNA	F	N	20MAR92	20MAR92	AD	AD	~320	~320	766	70	0.0
TGA-01	MARY	F	N	26JUL89	26JUL89	AD	AD	330	330	285	100	0.0
TGA-02	TORY	M	N	10MAR95	10MAR95	AD	AD	295	295	166	100	0.0
TGA-03	MARMONTEL	F	N	10MAR95	10MAR95	AD	AD	304	304	388	87	0.0
TGA-04	MERCURY	F	N	12MAR96	12MAR96	AD	AD	330	330	80	100	0.0
TJX-01	CONNIE	F	Y	26MAY89	11SEP90	AD	AD	279	271	353	55	15.5
TJX-02	PATIENCE	F	N	02MAY91	02MAY91	AD	AD	284	284	368	25	0.0
TJX-03	FRECKLES	F	N	19OCT93	19OCT93	SU	SU	245	245	216	100	0.0

Manatee ID	Name	Sex	Captive?	Date of Capture	Date of Release	Age Class at Capture	Age Class at Release	Length (cm) at Capture	Length (cm) at Release	No. Days Tracked	% Tracking Period	Months in Captivity
TMI-01	BOB	M	Y	16JUL90	10DEC90	AD	AD	303	303	600	47	4.8
TMI-02	FERGIE	F	N	02SEP92	02SEP92	AD	AD	265	265	458	100	0.0
TMI-03	CLOCKWORK	M	N	11FEB94	11FEB94	AD	AD	.	.	192	100	0.0
TNC-01	DIANE	F	N	11MAR87	11MAR87	AD	AD	330	330	755	46	0.0
TNC-02	JESSE	M	N	11MAR87	11MAR87	AD	AD	305	305	52	100	0.0
TNC-03	TAMMY	F	N	25FEB88	25FEB88	AD	AD	315	315	138	5	0.0
TNC-04	PAT	F	N	25FEB88	25FEB88	AD	AD	310	310	56	100	0.0
TNC-05	ROSEANNE	F	N	18JAN89	18JAN89	AD	AD	340	340	133	100	0.0
TNC-06	NANCY	F	N	18JAN89	18JAN89	SU	SU	250	250	188	22	0.0
TNC-07	WHITIE	M	N	16MAR89	16MAR89	SU	SU	250	250	138	100	0.0
TNC-08	GEORGE	M	N	16MAR89	16MAR89	AD	AD	275	275	61	100	0.0
TNC-09	JANATEE	F	N	12MAR95	12MAR95	AD	AD	270	270	160	100	0.0
TNC-10	MARCH	F	N	12MAR95	12MAR95	AD	AD	330	330	394	88	0.0
TNC-11	VALE	M	N	12MAR95	12MAR95	SU	SU	257	257	49	100	0.0
TNC-12	MOSSIE	M	N	13MAR96	13MAR96	AD	AD	290	290	79	100	0.0
TPE-01	SPOT	F	N	27JAN89	27JAN89	AD	AD	315	315	1083	56	0.0
TPE-02	FIREBALL	F	N	15FEB89	15FEB89	AD	AD	~325	~325	165	78	0.0
TPE-03	SICKLE	F	N	19DEC89	19DEC89	AD	AD	335	335	535	39	0.0
TPE-04	SUSAN	F	Y	23JUL90	21AUG90	AD	AD	304	304	489	29	1.0
TRB-01	SONNY	M	N	13FEB92	13FEB92	AD	AD	~315	~315	1543	98	0.0

Age Class Definitions: 'CB' (captive-born), 'OR' (orphaned calf), 'CA' (dependent calf born in wild, with mother), 'SU' (independent immature, < 265 cm length), 'AD' (independent mature). Individuals are considered adults if they are at least 265 cm in length, at least 5 years old, or (for females) are known to have given birth to a calf.

Appendix 1b. Radio-tagged manatee identity database for the Atlantic coast of Florida and Georgia, from May 1986 through May 1996, showing capture and release locations and method of capture. SAS database name = tagmanid.sd2. N = 83 individuals.

Manatee ID	Manatee Name	Capture Location	Release Location	Capture Method
TBC-01	DIXIE	BANRIVUP:MSS	BANRIVUP:MSS	NETCAPT
TBC-02	TRIXIE	BANRIVUP:MSS	BANRIVUP:MSS	NETCAPT
TBC-03	MOON	BANRIVMID:CCS	BANRIVMID:CCS	FREETAG
TBC-04	ECLIPSE	BANRIVMID:CCS	BANRIVMID:CCS	NETCAPT
TBC-05	GYRO	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-06	MOE	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-07	BILL	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-08	ANGELA	BANRIVUP:MSS	BANRIVUP:MSS	NETCAPT
TBC-09	C-COW	BANRIVMID:CCS	BANRIVMID:CCS	FREETAG
TBC-10	FRAN	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-11	GLORIA	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-12	HEIKE	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-13	IRENE	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-14	JEROME	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-15	KAREN	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-16	LARRY	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-17	MADONNA	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-18	LEROY	BANCRK:EBASIN	BANCRK:EBASIN	NETCAPT
TBC-19	SHARON	BANRIVUP:MSS	BANRIVUP:MSS	NETCAPT
TBC-20	RUTH	BANRIVUP:MSS	BANRIVUP:MSS	NETCAPT
TBC-21	WILLIE	BANRIVUP:MSS	BANRIVUP:MSS	NETCAPT
TBC-22	MAGOO	BANRIVUP	BANRIVUP:MSS	CAPTREL
TBC-23	HILLARY	HALIFAXRIV:OAKHILL	BANRIVUP:MSS	CAPTREL
TBC-24	BETTY	BANRIVMID:CCS	BANRIVMID:CCS	FREETAG
TBC-25	D-COW	BANRIVMID:CCS	BANRIVMID:CCS	NETCAPT
TBC-26	PEEWEE	BANRIVMID:CCS	BANRIVMID:CCS	FREETAG
TBC-27	MEL	INDRIVMID:MELBOURNE	BANRIVUP:NASACWY	CAPTREL
TBC-28	LIBERTY	BANRIV:SYKESCRK	BANRIVUP:NASACWY	CAPTREL
TBC-29	CASEY	PORTEVERGL:PPINTAKE	INDRIVUP:PORTSTJOHN	CAPTREL
TBC-30	MARIA	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-31	FREDDIE	BANCRK:HWY3	BANCRK:HWY3	NETCAPT
TBC-32	TOMASINA	BANRIVMID:CCS	BANRIVMID:CCS	FREETAG
TBC-33	ERNIE	INDRIVUP:HAULOVERCNL	BANRIVUP:NASACWY	CAPTREL
TBC-34	MILEY	BANCRK	BANCRK:HWY3	CAPTREL
TBC-35	E-COW	BANRIVMID:E528CWY	BANRIVMID:E528CWY	NETCAPT
TBC-36	SUNSHINE	BANRIVMID:CCS	BANRIVMID:CCS	FREETAG

Manatee ID	Manatee Name	Capture Location	Release Location	Capture Method
TBC-37	PAMELA	STLUCIE:PPINTAKE	BANRIVUP:MSS	CAPTREL
TBC-38	ADAIR	INDRIVUP:FPLPP	BANRIVUP:MSS	CAPTREL
TBC-39	LYDIA	CAPTIVE-BORN	BANRIVUP:MSS	CAPTREL
TBC-40	DANISE	INDRIVMID:MELBOURNE	BANRIVUP:NASACWY	CAPTREL
TBC-41	SCOTT	RIVIERABCH:PP	BANRIVUP:NASACWY	CAPTREL
TBC-42	CHESSIE	CHESAPEKBAY:CHESTRIV	BANRIVUP:NASACWY	CAPTREL
TBC-43	ROBBIE	BANRIVMID:W528CWY	BANRIVMID:W528CWY	NETCAPT
TBC-44	MOOSE	HALIFAXRIV	BANRIVUP:NASACWY	CAPTREL
TBC-45	HARVEY	CAPTIVE-BORN	BANRIVUP:NASACWY	CAPTREL
TBC-46	FOSTER	CAPTIVE-BORN	BANRIVUP:NASACWY	CAPTREL
TBC-47	INDY	CAPTIVE-BORN	BANRIVUP:NASACWY	CAPTREL
TFK-01	MANNY	FLKEYS:KEYLARGO	FLKEYS:KEYLARGO	CAPTREL
TFK-02	STAN	FLKEYS:TAVERNIER	FLKEYS:TAVERNIER	FREETAG
TFK-03	OLLIE	FLKEYS:TAVERNIER	FLKEYS:TAVERNIER	FREETAG
TFP-01	HUTCH	STLUCIE:HUTCHINSONIS	STLUCIE:JENSENBCH	CAPTREL
TFP-02	ROSS	PORTEVERGL:PPINTAKE	HOBESOUND	CAPTREL
TFP-03	NATALIE	STLUCIE:PPINTAKE	STLUCIE:PP	CAPTREL
TFP-04	SOPHIA	STLUCIE:JENSENBCH	STLUCIE:JENSENBCH	FREETAG
TFP-05	LANI	JUPITER:SOUND	JUPITER:SOUND	FREETAG
TFP-06	VANNA	FTPIERCE:PPDISCH	FTPIERCE:PPDISCH	FREETAG
TGA-01	MARY	KINGSBAY,GA	KINGSBAY,GA	FREETAG
TGA-02	TORY	BRUNSWICK:GAPAC	BRUNSWICK:GAPAC	NETCAPT
TGA-03	MARMONTEL	BRUNSWICK:GAPAC	BRUNSWICK:GAPAC	NETCAPT
TGA-04	MERCURY	BRUNSWICK:GAPAC	BRUNSWICK:GAPAC	NETCAPT
TJX-01	CONNIE	STJOHNRIV:DRSINLET	STJOHNRIV:ORANGEPK	CAPTREL
TJX-02	PATIENCE	STAUGUST:GUANALAKE	STAUGUST:GUANALAKE	RESCUE
TJX-03	FRECKLES	STAUGUST:GUANARIVPK	STAUGUST:GUANARIVPK	RESCUE
TMI-01	BOB	PORTEVERGL:PPINTAKE	BISCBAY:MATHESONHAM	CAPTREL
TMI-02	FERGIE	BISCBAY:DEERINGBAY	BISCBAY:DEERINGBAY	RESCUE
TMI-03	CLOCKWORK	MIAMI:LITTLERIV	MIAMI:LITTLERIV	FREETAG
TNC-01	DIANE	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT
TNC-02	JESSE	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT
TNC-03	TAMMY	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT
TNC-04	PAT	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT
TNC-05	ROSEANNE	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT
TNC-06	NANCY	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT
TNC-07	WHITIE	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT
TNC-08	GEORGE	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT
TNC-09	JANATEE	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT
TNC-10	MARCH	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT
TNC-11	VALE	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT

Manatee ID	Manatee Name	Capture Location	Release Location	Capture Method
TNC-12	MOSSIE	FERNBCH:CONTCORP	FERNBCH:CONTCORP	NETCAPT
TPE-01	SPOT	PORTEVERGL:PPDISCH	PORTEVERGL:PPDISCH	FREETAG
TPE-02	FIREBALL	PORTEVERGL:PPDISCH	PORTEVERGL:PPDISCH	FREETAG
TPE-03	SICKLE	PORTEVERGL:PPDISCH	PORTEVERGL:PPDISCH	FREETAG
TPE-04	SUSAN	PORTEVERGL:PPINTAKE	INDRIVUP:PORTSTJOHN	CAPTREL
TRB-01	SONNY	RIVIERABCH:PPDISCH	RIVIERABCH:PPDISCH	FREETAG

NOTE: Meaning of Capture Method. CAPTREL = Tag and release a captive rehabilitated manatee. FREETAG = Attach belt harness and radio-tag assembly in water on an unrestrained wild manatee. NETCAPT = Capture and restrain a free-ranging manatee with net; tag and release on site. RESCUE = Same as NETCAPT but purpose was to rescue the manatee (e.g., to remove line entanglement and assess condition); tag and release on site.

Appendix 2. Description of the types of sensor data collected from satellite-monitored PTTs, including technical information on the manner in which the data were formatted in the transmitted message.

TYPES OF SENSOR DATA

1. PTT Temperature: The temperature sensor yields "counts" that are converted to temperature using a calibration curve provided by Telonics. We determine a 4th-order polynomial through five points (from 0° - 40° C, at 10-degree intervals) to make the conversion. Each PTT has a unique calibration curve and polynomial equation; this changes only if the PTT's motherboard is replaced, which is rare (B. Burger, Telonics, pers. comm. to J. Reid).

Bits (maximum value): 16 (65,535), 14 (16,383), or 8 (255). A scaling factor needs to be multiplied times the raw sensor counts before fitting to the temperature calibration curves: 1 (16-bit); 4 (14-bit); or 142.222 (8-bit).

Note: The sensor is located within the tag housing; therefore, it may be affected by solar radiation and is likely to show a time lag in temperature change.

Note: The maximum value for an 8-bit variable yielded maximum temperatures of only about 27° - 32 °C for four new PTT's deployed in March 1995. This problem needs to be investigated.

Accuracy: According to Bill Burger of Telonics, the sensor is only accurate to about ± 2 °C.

Precision: At the poorest level of precision used (8-bit value), my "eyeball" estimate of precision is about 0.2 °C. Precision improves when a larger number of bits are used to carry the information.

2. Low Battery Voltage Flag: A non-zero value (1 or 3) indicates that the battery voltage is low and the PTT will stop transmitting in several days (~ 4 - 9 days, J. Reid and R. Bonde, pers. comm.).

Bits: 1 (values 0 or 1) or 2 (values 0 - 3).

Note: For a 2-bit specification, the values of 1 and 2 are erroneous.

3. Short-term (1-hr) Activity Index: This counter gives the number of minutes in the preceding 60-minute period in which a motion-sensitive switch inside the PTT housing was triggered at least once. The switch is triggered by a tip of 90° or more from the vertical.

Bits (max. value): 6 (63).

Note: The maximum value, by definition, cannot exceed 60.

4. Long-term (12-hr) Activity Index: This counter gives the number of seconds in which a motion-sensitive switch inside the PTT housing was triggered in the preceding 12-hr period (this period is specified by the user). The switch is triggered by a tip of 90° or more from the vertical.

Bits (max. value): 10 (1023).

Note: The 12-hr period begins with the cut-on time (typically between 0700-0900 EST), so it approximates activity in daytime and nighttime periods. Daytime transmissions give the nighttime activity value until 12 hrs from the cut-on time; the daytime activity value is transmitted starting in the evening and through the night.
Note: There are 43,200 sec per 12-hr period. So a maximum tip count occurs when the sensor is triggered an average of once per 42 sec (or 1.43 tips/min). The maximum tip count could be increased by changing the Activity Count Scaling factor (currently = 1) to a larger number.

5. Saltwater Switch (SWS) Fail-safe Flag: This flag indicates that the SWS is functioning properly (0) or has failed (1) and is being overridden. The failsafe timeout period was set at 2 hrs for the four PTT's deployed in March 1995. If the switch senses conductivity (i.e., presence of saltwater) for a continuous period of greater than 2 hrs, the flag changes to a value of 1; then the SWS function is overriden, allowing the PTT unit to operate according to programmed duty cycle.
Bits (max. value): 1 (1)

6. Average Dive Time (in seconds) over "AVGINT" hours: The average duration that the PTT cap was underwater during the preceding "AVGINT" hours (chosen to be 4 hrs). The raw value must be multiplied by the chosen Dive Time Scaling Factor (5) to obtain the average dive time in seconds.
Bits (max. value): 6 (63) ==> Max. Aver. Dive Time = 315 sec (5.25 min)
Note: Dive durations less than a specified value (chosen to be 5 sec) are excluded from the calculations.
Note: Dive times refer to the behavior of the PTT, not the manatee!

7. Dive Count over "AVGINT" hours: The number of times that the PTT became submerged during the preceding "AVGINT" hours (chosen to be 4 hrs). Must multiply the raw value by the chosen Dive Count Scaling Factor (5) to obtain total dive count.
Bits (max. value): 6 (63)
Note: Dive lasting less than a specified value (chosen to be 5 sec) are excluded from the total count.
Note: Dive times refer to the behavior of the PTT, not the manatee!
Note: Dive Count X Average Dive Time = Total Time PTT Submerged
(Total Time/AVGINT in seconds) X 100 = % Time PTT Submerged

SENSOR DATA FORMATS

The data stream following the PTT identification code is comprised of 32 bits (4 bytes). Argos specifies that sensor data must arrive in 32-bit blocks. We use all 32 bits, in various combinations for the different sensors. Five sensor formats have been used. The first one (Format 0) used with Beauregard in 1985 included two 8-bit temperature words (combined in a formula to calculate PTT temperature) and two activity indices. Sensor data (Format 1) for East coast manatees included PTT temperature, short-term activity, and long-term activity. The next sensor format (Format 2) was a "software upgrade" by Telonics that added a low-battery voltage flag. The last programmed format (Format 3) incorporated a saltwater switch to yield information on diving behavior and to increase the efficiency of transmissions (only transmitting when at the surface), and dropped short-term activity. Another sensor format (Format 4) was generated in the dataset when Telonics upgraded the software from Format 1 to Format 2 but Argos was not immediately informed of the change. Consequently, Argos reported a 16-bit value that was actually 2 bits (usually a value of 0) for the low voltage flag followed by 14 bits for temperature. Sensor data from some PTT's therefore follow Formats 2 and 4.

No. Bits for each Sensor

	Format 0	Format 1	Format 2	Format 3	Format 4 *
No. Sensors	3	3	4	6	4
Low Battery Flag			2	1	[2]
Temperature	8 + 8 †	16 (1)	14 (4)	8 (142.222)	[14 (4)]
Short-term Activity	6	6	6		6
Long-term Activity	10	10	10	10	10
SWS Failsafe Flag				1	
Aver. Dive Time				6 (5)	
Dive Count				6 (5)	

* Same as Format 2, except Argos reported the low battery flag and temperature as one 16-bit value.

† Two temperature words were combined in a formula to calculate temperature (°C):

$$\frac{[(A \cdot 256) + B] - 33{,}531.6}{808.11}$$

Note: Scaling Factor is given in parentheses, if not equal to 1. Multiply raw sensor value times the scaling factor to calculate the actual value.

Note: The sensor order in the Argos output datasets is as shown above for formats 1, 2 and 4. Variables are listed in the following order for Format 3: Temperature, Low Battery Voltage Flag, SWS Failsafe Flag, Average Dive Time, Dive Count, and Long-term Activity. The meaning and order of the Format 0 activity indices are unclear.

Format 4 applies to five PTT's over the following dates of operation, up until 1245 hr EST on 26Jan95 (except for PTT No. 9993, changed on 02Dec95); then Format 2 is in effect.

PTT ID No. 9648 19 July 1993 Software Upgrade (from Format 1 to 2)
- 21Oct93 - 05Dec93 Fergie
- 20Dec93 - 12Apr94 Spot
- 29Apr94 - 04May94 Hillary
- 25May94 - 25Aug94 Vanna
- 30Aug94 - 15Sep94 Moose (in pen)
- 26Jan95, 1245 hr Argos changed sensor format to correspond to Format 2.

PTT ID No. 9990 19 July 1993 Software Upgrade (from Format 1 to 2)
- 19Oct93-04Dec93 Stan
- 09Dec93-16Feb94 Stan

(Unit was sent to Telonics on 30Mar94 and was not repairable.)

PTT ID No. 9993 19 July 1993 Software Upgrade (from Format 1 to 2)
- 11Feb94-26Aug94 Clockwork (Format 4)
- 02Dec95 Argos changed sensor format to correspond to Format 2.

PTT ID No. 9995 3 August 1994 Software Upgrade (from Format 1 to 2)
- 07Oct94 - 18Oct94 Chessie
- 12Jan95 - >26Jan95 Chessie
- 26Jan95, 1245 hr Argos changed sensor format to correspond to Format 2.

PTT ID No. 9999 19 July 1993 Software Upgrade (from Format 1 to 2)
- 04Jan94 - 17Jan94 Sonny
- 24Oct94 - Ongoing Sonny
- 26Jan95, 1245 hr Argos changed sensor format to correspond to Format 2.

Sensor data reported by Argos for the following PTT was incorrectly changed from Format 1 to Format 2 on 26 January 1995 (1245 EST). This mistake was corrected on 12 July 1995 (1000 EST). Since this problem only affects a short period (28 Jun 1995 - 12 July 1995) for one animal (TBC-43, Robbie), and would require conversion of the values back to binary first, these temperature data will just be deleted.

PTT ID No. 9997
- 27Dec88 - 26Jan95 Format 1 (16,6,10)
- 26Jan95, 1245 hr Argos changed sensor format to correspond to Format 2.
- 26Jan95(1245EST)-12Jul95(1000EST) Format ??
  Counted as 16,6,10, but reported as 2,14,6,10.
- 12Jul95 - 31Dec99 Format 1 (16,6,10)

The sensor data are reported by Argos for *each message* that is received, resulting in several or many messages per location. The compression index indicates the number of identical consecutive messages received. In order to condense the sensor information into one observation per fix, the following protocol will be used:

Temperature -- median count, weighted by compression index. Temperature can change from one message to the next.

Short-term Activity -- modal count, weighted by compression index. This changes at the end of each hour.

Long-term Activity -- modal count, weighted by compression index. This changes at the end of each 12-hour period.

Dive Count and Average Dive Time -- modal count, weighted by compression index. This changes at the end of each 4-hour period.

Appendix 3. Changes in PTT duty cycles and turn-on times used for radio-tracking manatees along the east coast of Florida and Georgia from May 1986 to May 1996. The periods over which different duty cycles were employed overlapped because the cycles could only be changed by technicians at Telonics. Likewise, changes in turn-on times did not occur instantaneously because they could only be made by Sirenia Project staff after the PTT units were retrieved from the animals.

Years: 1986 - 1987
Duty Cycle: 1 hr ON - 4 OFF - 3 ON - 3 OFF - 3 ON - 10 OFF
Period On per 24-hr Cycle: 7 hr
Turn-on Time: 0200 hr EST
Notes: The first year of tracking on the Atlantic coast used the same duty cycle as was used for the three manatees tracked in southwest Florida in 1986.

ON TIMES (EST)/[GMT]	OFF TIMES
0200 - 0300 [0700-0800]	
	0300 - 0700
0700 - 1000 [1200-1500]	
	1000 - 1300
1300 - 1600 [1800-2100]	
	1600 - 0200

Year 1987-1988+:
Duty Cycle: 2 hr ON - 5 OFF - 2 ON - 2 OFF - 2 ON - 7 OFF - 2 ON - 2 OFF
Period On per 24-hr Cycle: 8 hr
Turn-on Time: 0630 hr EST
Notes: Some PTT's in 1987 (and maybe 1986?) had this programmed duty cycle and at least one PTT continued with this duty cycle until July 1993.

ON TIMES (EST)/[GMT]	OFF TIMES
0630 - 0830 [1130-1330]	
	0830 - 1330
1330 - 1530 [1830-2030]	
	1530 - 1730
1730 - 1930 [2230-0030]	
	1930 - 0230
0230 - 0430 [0730-0930]	
	0430 - 0630

Years 1987 - 1996:

Duty Cycle: 2 hr ON - 4 OFF - 2 ON - 3 OFF - 2 ON - 6 OFF - 2 ON - 3 OFF

Period On per 24-hr Cycle: 8 hr

Turn-on Time: Variable (0630 - 0900 hr EST); 0700 hr in 1987 and 1989.

Notes: During 1987-1988 some PTT's used this duty cycle, as well as those listed above. The turn-on time has been changed many times over the course of the study in order to better match PTT transmission periods to times of satellite overpasses. Only the most recent changes in turn-on times are listed below. See the PTT log records for turn-on times for each tag in different years.

Time Period: < Spring 1994 to August / Fall 1994

ON TIMES (EST)	/[GMT]	OFF TIMES
0730 - 0930	[1230-1430]	
		0930 - 1330
1330 - 1530	[1830-2030]	
		1530 - 1830
1830 - 2030	[2330-0130]	
		2030 - 0230
0230 - 0430	[0730-0930]	
		0430 - 0730

Time Period: August / Fall 1994 to Winter / Spring 1995

The turn-on time was changed on 9 August 1994, starting with the captive-release animal "Scott" & the PTT Accuracy Experiment. Other tagged manatees were changed later in the year as PTTs were switched. The change in timing was necessary due to drifting of the NOAA-11 satellite such that the current duty cycle was not optimal for the overpass times. Service Argos offered free multi-satellite processing during this period, adding a third satellite (NOAA-9) in addition to NOAA-11 and -12. We changed the turn-on time from 0730 hr EST to 0900 hr EST to cover the NOAA-9 and -11 overpasses. The programmed duty cycle remained as above.

ON TIMES (EST)	/[GMT]	OFF TIMES
0900 - 1100	[1400-1600]	
		1100 - 1500
1500 - 1700	[2000-2200]	
		1700 - 2000
2000 - 2200	[0100-0300]	
		2200 - 0400
0400 - 0600	[0900-1100]	
		0600 - 0900

Time Period: Winter / Spring 1995 to Spring (March) 1996

On 1 Feb 1995, Argos replaced the NOAA-11 satellite which had been drifting out of orbit with NOAA-14. This reinstated a "normal" pattern of overpasses. Since we had altered the turn-on time last year to hit NOAA-9 and -11, there was a large reduction in late afternoon (1600 hr) and early morning (0500 hr) locations after the switch in satellite operation. The turn-on time was changed to 0700 hr on 10 and 12 March 1995 for 5 manatees tagged by GA DNR (Brunswick, GA & Fernandina Beach, FL). Subsequently, the same was done for tagged manatees when PTTs were switched. The programmed duty cycle remained as above.

ON TIMES (EST)/[GMT]	OFF TIMES
0700 - 0900 [1200-1400]	
	0900 - 1300
1300 - 1500 [1800-2000]	
	1500 - 1800
1800 - 2000 [2300-0100]	
	2000 - 0200
0200 - 0400 [0700-0900]	
	0400 - 0700

Time Period: Spring (March) 1996 - Present

ON TIMES (EST)/[GMT]	OFF TIMES
0630 - 0830 [1130-1330]	
	0830 - 1230
1230 - 1430 [1730-1930]	
	1430 - 1730
1730 - 1930 [2230-0030]	
	1930 - 0130
0130 - 0330 [0630-0830]	
	0330 - 0630

Appendix 4a. Printout of the tagging history lookup table (lkuptags.sd2) for manatees radio-tagged along the Atlantic coast of Florida and Georgia between May 1986 and May 1996. See note following table for variable labels.

	ID	NAME	BOUT	TAGNO	TAG TYPE	BELT	TETHER	ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
1	TBC-01	DIXIE	0	584	VHF	30P	208	08MAY86	10:45	NET TAG	22MAY86	14:00	20	REP TX; TO PTT	14.1
2	TBC-01	DIXIE	1	10022	PTT	30P	208	22MAY86	14:00	REP TX	28MAY86	20:07	1	LAST LOC; 28MAY86 REC TX; WL	6.3
3	TBC-01	DIXIE	0	508	VHF	30P	225	24JAN87	12:00	RETAGGED	01JUL87	12:00	18	LAST LOC; 26JAN88 REM TX; BOAT DESTROYED	158.0
4	TBC-01	DIXIE	2	10024	PTT	30P	0	26JAN88	13:00	RETAGGED	17JUN88	4:14	4	LAST LOC; 29JUN88 REC TX; EYEBOLT BROKEN	142.6
5	TBC-02	TRIXIE	1	10020	PTT	57Y	208	08MAY86	9:15	NET TAG	18JUN86	13:00	2	LAST LOC; 19FEB88 REM BLT; REC TX; WL	41.2
6	TBC-03	MOON	0	508	VHF	45Y	0	30SEP86	12:00	FREE TAG	02OCT86	15:00	20	REP TX; TO PTT	2.1
7	TBC-03	MOON	1	10021	PTT	45Y	0	02OCT86	15:00	REP TX	06NOV86	3:13	1	LAST LOC; 06NOV86 REC TX; WL	34.5
8	TBC-03	MOON	0	508	VHF	45Y	225	12NOV86	12:00	RETAGGED	12DEC86	12:00	1	REC TX; WL	30.0
9	TBC-03	MOON	2	10024	PTT	45Y	225	09JAN87	12:00	RETAGGED	18JAN87	17:30	17	REP TX; PTT MALFUNCT (DIPLEXER)	9.2
10	TBC-03	MOON	3	10023	PTT	45Y	225	18JAN87	17:30	REP TX	28JAN87	14:49	1	LAST LOC; 23MAR88 REC TX; WL	9.9
11	TBC-03	MOON	0	730	VHF	45Y	225	30JUN87	12:00	RETAGGED	05JUL87	12:00	1	REC TX; WL	5.0
12	TBC-03	MOON	0	730	VHF	45Y	230	18AUG87	12:00	RETAGGED	19NOV87	12:45	20	REP TX; TO PTT	93.0
13	TBC-03	MOON	4	10025	PTT	45Y	230	19NOV87	12:45	REP TX	16MAR88	11:30	16	REP TX; PTT MALFUNCT (ANT MISSING)	117.9
14	TBC-03	MOON	5	10023	PTT	45Y	230	16MAR88	11:30	REP TX	23MAR88	5:03	1	LAST LOC; 23MAR88 REC TX; WL	6.7
15	TBC-03	MOON	0	730	VHF	45Y	230	04MAY88	12:00	RETAGGED	12AUG88	13:45	16	REP TX; TX MALFUNCT (ANT MISSING)	100.1
16	TBC-03	MOON	0	740	VHF	45Y	230	12AUG88	13:45	REP TX	03NOV88	12:00	1	REC TX; WL	82.9
17	TBC-03	MOON	6	9991	PTT	45Y	215	22DEC88	10:30	RETAGGED	23FEB89	18:04	1	LAST LOC; 26FEB89 REC TX; WL	63.3
18	TBC-03	MOON	0	780	VHF	45Y	230	26APR89	12:00	RETAGGED	05JUL89	12:00	16	REP TX; TX MALFUNCT (ANT MISSING)	70.0
19	TBC-03	MOON	0	612	VHF	45Y	230	05JUL89	12:00	REP TX	09AUG89	10:00	20	REP TX; TO PTT	34.9
20	TBC-03	MOON	7	9995	PTT	45Y	230	09AUG89	10:00	REP TX	15AUG89	10:00	25	REP TX BLT; BELT WORN	6.0
21	TBC-03	MOON	8	9995	PTT	103Y	230	15AUG89	10:00	REP BLT	18OCT89	12:30	17	REP TX; PTT MALFUNCT (BATT FAIL)	64.1
22	TBC-03	MOON	0	438	VHF	103Y	230	18OCT89	12:30	REP TX	15NOV89	15:30	20	REP TX; TO PTT	28.1
23	TBC-03	MOON	9	9998	PTT	103Y	230	15NOV89	15:30	REP TX	31DEC89	14:28	18	LAST LOC; 5JAN90 REC HOUSING; BOAT	46.0
24	TBC-03	MOON	0	646	VHF	103Y	215	05JAN90	12:00	RETAGGED	15JAN90	14:30	6	REC TX; CONN UNSCREWED	10.1
25	TBC-03	MOON	0	470	VHF	103Y	220	30MAY90	13:00	RETAGGED	08AUG90	12:30	19	REP TX; ?????	70.0
26	TBC-03	MOON	0	438	VHF	103Y	220	08AUG90	12:30	REP TX	31OCT90	12:38	20	REP TX; TO PTT	84.0
27	TBC-03	MOON	10	9644	PTT	103Y	220	31OCT90	12:38	REP TX	16JAN91	15:00	15	REP TX; LOW BATT	77.1
28	TBC-03	MOON	11	9996	PTT	103Y	220	16JAN91	15:00	REP TX	03MAR91	4:04	5	LAST LOC; 8MAR91 REC PTT; SWIVEL FAIL	45.5
29	TBC-03	MOON	0	740	VHF	103Y	230	25MAY91	9:30	RETAGGED	05JUN91	11:00	25	REP TX & BLT; BLT & BUCKLE WORN	11.1
30	TBC-03	MOON	0	438	VHF	125NY	230	05JUN91	11:00	REP TX & BLT	13AUG91	11:00	16	REP TX; TX MALFUNCT (ANT MISSING)	69.0
31	TBC-03	MOON	0	673	VHF	125NY	230	13AUG91	11:00	REP TX	22SEP91	12:00	1	REC TX; WL	40.0

(Appendix 4a continued on next page)

Appendix 4a (continued)

	ID	NAME	BOUT	TAGNO	TAG TYPE	BELT	TETHER	ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
32	TBC-03	MOON	0	612	VHF	125NY	210	20JAN92	15:00	RETAGGED	10FEB92	13:15	19	REP TX; TO BETTER UNIT & TETHER	20.9
33	TBC-03	MOON	0	730	VHF	125NY	225	10FEB92	13:15	REP TX	17FEB92	11:00	20	REP TX; TO PTT	6.9
34	TBC-03	MOON	12	10027	PTT	125NY	225	17FEB92	11:00	REP TX	16APR92	17:30	15	REP TX; LOW BATT	59.3
35	TBC-03	MOON	13	9644	PTT	125NY	225	16APR92	17:30	REP TX	17JUL92	11:30	16	REP TX; MALFUNCT	91.8
36	TBC-03	MOON	0	637	VHF	125NY	225	17JUL92	11:30	REP TX	06AUG92	11:00	20	REP TX; TO PTT	20.0
37	TBC-03	MOON	14	2101	PTT	125NY	225	06AUG92	11:00	REP TX	23NOV92	13:45	15	REP TX; LOW BATT	109.1
38	TBC-03	MOON	15	9646	PTT	125NY	225	23NOV92	13:45	REP TX	20FEB93	21:00	35	LAST LOC; PTT MIA	89.3
39	TBC-03	MOON	16	2104	PTT	47Y	53	21OCT93	10:25	FREE TAG	22FEB94	8:45	10	LAST LOC; 06MAR94 REC TX BLT; BLT BROKEN	123.9
40	TBC-04	ECLIPSE	1	10022	PTT	58Y	215	03OCT86	12:30	NET TAG	21JAN87	7:06	31	LAST LOC; PTT LOST; WL; BOAT	109.8
41	TBC-04	ECLIPSE	0	584	VHF	58Y	215	29JAN87	12:00	RETAGGED	25FEB87	13:15	20	REP TX; TO PTT	27.1
42	TBC-04	ECLIPSE	2	10023	PTT	58Y	215	25FEB87	13:15	REP TX	30MAY87	15:45	10	LAST LOC; 16JUN87 REC TX BLT; BLT BROKEN	94.1
43	TBC-05	GYRO	1	10021	PTT	R	225	13NOV86	13:30	NET TAG	17JUN87	10:15	15	REP TX; LOW BATT	215.9
44	TBC-05	GYRO	2	10020	PTT	R	225	17JUN87	10:15	REP TX	09AUG87	3:20	1	LAST LOC; 11AUG87 REC TX; WL	52.7
45	TBC-05	GYRO	0	604	VHF	93R	225	29MAR88	18:47	NET RETAGGED	16MAY88	12:00	1	REC TX; WL	47.7
46	TBC-06	MOE	0	355	VHF	6R	215	20APR87	14:25	NET TAG	18NOV88	15:00	20	REP TX; TO PTT	578.0
47	TBC-06	MOE	1	10023	PTT	6R	215	18NOV88	15:00	REP TX	28MAY89	9:51	1	LAST LOC; 30MAY89 REC TX; WL	190.8
48	TBC-06	MOE	0	546	VHF	6R	210	16MAR90	10:15	RETAGGED SAFETY	22MAR90	10:15	20	REP TX; TO PTT	6.0
49	TBC-06	MOE	2	9640	PTT	6R	220	22MAR90	10:15	REP TX	25MAY90	8:45	7	LAST LOC; 10APR91 REC PTT; BOAT & SUNK	63.9
50	TBC-06	MOE	0	470	VHF	6R	210	28NOV90	10:20	RETAGGED SAFETY	04DEC90	15:30	19	REP TX; TO TX	6.2
51	TBC-06	MOE	0	720	VHF	6R	225	04DEC90	15:30	REP TX	09DEC90	13:15	6	REC TX; SM CONN UNSCREWED	4.9
52	TBC-07	BILL	0	612	VHF	71R	215	22APR87	13:25	NET TAG	25JUN87	12:00	3	REC TX; WL (ALLIGATOR)	63.9
53	TBC-08	ANGELA	0	567	VHF	47B	225	23APR87	9:00	NET TAG	15JUN87	12:00	30	LAST LOC; TX LOST; 4SEP87 REC BLT; DEAD	53.1
54	TBC-09	C-COW	0	380	VHF	2Y	215	16JUN87	11:50	FREE TAG	11NOV87	12:00	30	LAST LOC; TX LOST; WL	148.0
55	TBC-09	C-COW	1	10020	PTT	2Y	225	28JAN88	11:30	RETAGGED	27MAR88	19:00	30	LAST LOC; PTT LOST; WL	59.3
56	TBC-09	C-COW	0	722	VHF	2Y	225	05MAY88	12:00	RETAGGED	27JUL88	12:00	18	REP TX; BOAT STRIKE (TX MINUS CAP & ANT)	83.0
57	TBC-09	C-COW	0	780	VHF	2Y	225	27JUL88	12:00	REP TX	08DEC88	11:00	20	REP TX; TO PTT	134.0
58	TBC-09	C-COW	2	9993	PTT	2Y	225	08DEC88	11:00	REP TX	28DEC88	23:59	18	LAST LOC; 5JAN89 REP PTT; BOAT	20.5
59	TBC-09	C-COW	0	780	VHF	2Y	225	05JAN89	15:00	RETAGGED	09FEB89	13:30	20	REP TX; TO PTT	34.9
60	TBC-09	C-COW	3	9990	PTT	2Y	225	09FEB89	13:30	REP TX	13FEB89	10:30	16	REP TX; PTT MALFUNCT; O-RING LEAK	3.9
61	TBC-09	C-COW	0	496	VHF	2Y	225	13FEB89	10:30	REP TX	14JUN89	10:50	25	REP TX BLT; BELT WORN	121.0
62	TBC-09	C-COW	4	9995	PTT	85Y	230	14JUN89	10:50	REP TX & BLT	01AUG89	23:59	1	LAST LOC; 2AUG89 REC PTT; WL	48.5
63	TBC-09	C-COW	0	559	VHF	85Y	210	28OCT89	14:30	RETAGGED SAFETY	01NOV89	12:00	20	REP TX; TO PTT	3.9
64	TBC-09	C-COW	5	9993	PTT	85Y	225	01NOV89	12:00	REP TX	16NOV89	9:10	19	REP TX; REBALANCED PTT	14.9
65	TBC-09	C-COW	6	9999	PTT	85T	225	16NOV89	9:10	REP TX	08DEC89	19:30	1	LAST LOC; 09DEC89 REC TX; WL	22.4

(Appendix 4a continued on next page)

Appendix 4a (continued)

	ID	NAME	BOUT	TAGNO	TAG TYPE	BELT	TETHER	ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
66	TBC-09	C-COW	7	9999	PTT	85Y	235	13DEC89	13:15	RETAGGED	12JAN90	14:10	18	LAST LOC; 15JAN90 REP PTT; BOAT	30.0
67	TBC-09	C-COW	0	810	VHF	85Y	220	15JAN90	14:00	RETAGGED	31JAN90	8:30	20	REP TX; TO PTT	15.8
68	TBC-09	C-COW	8	9997	PTT	85Y	220	31JAN90	8:30	REP TX	04MAR90	12:00	18	REP TX; REMOVED PTT; BOAT	32.1
69	TBC-09	C-COW	0	496	VHF	85Y	220	04MAR90	12:00	REP TX	10MAR90	12:00	1	REC TX; WL	6.0
70	TBC-09	C-COW	0	685	VHF	85Y	210	08AUG90	13:00	RETAGGED SAFETY	08AUG90	18:30	19	REP TX; SAFETY	0.2
71	TBC-09	C-COW	0	100	VHF	85Y	210	08AUG90	18:30	REP TX SAFETY	09AUG90	15:15	20	REP TX; SAFETY TO PTT	0.9
72	TBC-09	C-COW	9	9641	PTT	85Y	230	09AUG90	15:15	REP TX	02OCT90	20:47	18	LAST LOC; 14NOV90 REM PTT; BOAT	54.2
73	TBC-09	C-COW	0	430	VHF	85Y	210	12DEC90	12:30	RETAGGED SAFETY	13DEC90	16:00	19	REP TX; SAFETY TO TX	1.1
74	TBC-09	C-COW	0	839	VHF	85Y	235	13DEC90	16:00	REP TX	13MAR91	12:00	30	LAST LOC; TX LOST; WL	89.8
75	TBC-09	C-COW	0	612	VHF	95R	235	22MAY91	12:00	RETAGGED TX BLT	31OCT91	12:35	20	REP TX; TO PTT	162.0
76	TBC-09	C-COW	10	10027	PTT	95R	235	31OCT91	12:35	REP TX	10FEB92	9:00	1	LAST LOC; REC PTT 14FEB92; WL	101.9
77	TBC-09	C-COW	11	7341	PTT	95R	230	12FEB92	13:15	RETAGGED	09APR92	14:45	19	REP TX; WITH BETTER UNIT	57.1
78	TBC-09	C-COW	12	9994	PTT	95R	230	09APR92	14:45	REP TX	02JUN92	13:30	19	REP TX; FOR BETTER UNIT	53.9
79	TBC-09	C-COW	0	590	VHF	95R	230	02JUN92	13:30	REP TX	04JUN92	11:00	4	REC TX; BROKEN EYE BOLT ON TX	1.9
80	TBC-09	C-COW	0	646	VHF	95R	230	04JUN92	11:00	RETAGGED	23JUN92	17:00	20	REP TX; TO PTT	19.3
81	TBC-09	C-COW	13	7342	PTT	95R	230	23JUN92	17:00	REP TX	05AUG92	11:45	15	REP TX; LOW BATT	42.8
82	TBC-09	C-COW	14	2100	PTT	95R	230	05AUG92	11:45	REP TX	08DEC92	12:00	15	REP TX, LOW BATT	125.0
83	TBC-09	C-COW	15	7348	PTT	95R	230	08DEC92	12:00	REP TX	11DEC92	8:52	1	LAST LOC; 14DEC92 REC TX; WL	2.9
84	TBC-09	C-COW	0	616	VHF	95R	0	14DEC92	12:00	RETAGGED	30DEC92	9:45	20	REP TX; TO PTT	15.9
85	TBC-09	C-COW	16	4025	PTT	95R	0	30DEC92	9:45	REP TX	13FEB93	15:00	5	LAST LOC; 14FEB93 REC PTT; WL	45.2
86	TBC-09	C-COW	0	720	VHF	95R	0	15FEB93	12:00	RETAGGED	24FEB93	14:00	20	REP TX; TO PTT	9.1
87	TBC-09	C-COW	17	4025	PTT	95R	53	24FEB93	14:00	REP TX	17JUN93	16:00	15	REP TX; LOW BATT	113.1
88	TBC-09	C-COW	18	7348	PTT	95R	53	17JUN93	16:00	REP TX	05JAN94	12:45	15	REP TX; LOW BATT	201.9
89	TBC-09	C-COW	19	7343	PTT	95R	53	05JAN94	12:45	REP TX	30JUN94	12:00	15	REP TX; LOW BATT	176.0
90	TBC-09	C-COW	20	7339	PTT	95R	53	30JUN94	12:00	REP TX	09FEB95	10:30	15	REP TX; LOW BATT	223.9
91	TBC-09	C-COW	21	7349	PTT	95R	53	09FEB95	10:30	REP TX	20APR95	15:25	25	REP BLT; BLT WORN; NET CAP	70.2
92	TBC-09	C-COW	22	7349	PTT	128NY	53	20APR95	15:25	NET CAP REP BLT	26AUG95	16:24	1	LAST LOC;27AUG95 REC PTT; WL	128.0
93	TBC-10	FRAN	0	646	VHF	82Y	225	16NOV87	14:38	NET TAG	21JAN88	12:00	7	REC TX; TX DESTROYED; BOAT	65.9
94	TBC-11	GLORIA	0	604	VHF	70Y	215	16NOV87	17:16	NET TAG	13JAN88	12:00	1	REC TX; WL	57.8
95	TBC-12	HEIKE	0	438	VHF	86R	225	17NOV87	14:35	NET TAG	12JAN88	17:00	16	REP TX; TX MALFUNCT (SUNK); CUT TETHER	56.1
96	TBC-12	HEIKE	0	730	VHF	86R	215	12JAN88	17:00	REP TX	15JAN88	12:00	1	REC TX; WL	2.8
97	TBC-13	IRENE	0	496	VHF	89R	210	17NOV87	16:00	NET TAG	07FEB88	12:00	16	REP TX; TX MALFUNCT (LEAK)	81.8
98	TBC-13	IRENE	0	470	VHF	89R	0	07FEB88	12:00	REP TX	27MAY88	15:00	16	REP TX; TX MALFUNCT (ANT MISSING)	110.1
99	TBC-13	IRENE	0	537	VHF	89R	0	27MAY88	15:00	REP TX	08JUL88	15:20	26	LAST LOC; 21DEC88 REM BLT; TX LOST; WL	42.0

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Appendix 4a (continued)

	ID	NAME	BOUT	TAGNO	TAG TYPE	BELT	TETHER	ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
100	TBC-14	JEROME	0	696	VHF	73R	215	17NOV87	16:00	NET TAG	28MAR88	12:00	10	REC TX BLT; BELT BROKEN	131.8
101	TBC-15	KAREN	0	670	VHF	81Y	215	18NOV87	11:50	NET TAG	13APR88	12:00	1	REC TX; WL (ANT MISSING)	147.0
102	TBC-15	KAREN	1	9991	PTT	81Y	215	02MAR89	16:30	RETAGGED	15MAY89	15:36	1	LAST LOC; 22MAY89 REC TX; WL	74.0
103	TBC-15	KAREN	0	470	VHF	81Y	230	13SEP89	19:00	RETAGGED	07OCT89	12:00	1	REC TX; WL	23.7
104	TBC-15	KAREN	0	790	VHF	81Y	0	31DEC89	10:30	RETAGGED	04JAN90	10:45	20	REP TX; TO PTT	4.0
105	TBC-15	KAREN	2	9997	PTT	81Y	0	04JAN90	10:45	REP TX	14JAN90	6:00	1	LAST LOC; 21JAN90 REC TX; WL	9.8
106	TBC-15	KAREN	3	9994	PTT	81Y	225	30MAY90	9:30	RETAGGED	13JUN90	5:05	1	LAST LOC; 14JUN90 REC TX; WL	13.8
107	TBC-16	LARRY	0	596	VHF	87R	215	18NOV87	10:59	NET TAG	22NOV87	14:00	10	REC TX BLT; BELT BROKEN	4.1
108	TBC-17	MADONNA	1	10021	PTT	97P	230	18NOV87	9:50	NET TAG	25DEC87	16:00	30	LAST LOC; PTT LOST; WL	37.3
109	TBC-18	LEROY	0	596	VHF	96G	215	30MAR88	13:20	NET TAG	03JUN88	14:45	20	REP TX; TO PTT	65.1
110	TBC-18	LEROY	1	10025	PTT	96G	215	03JUN88	14:45	REP TX	21JUN88	16:00	30	LAST LOC; PTT LOST; WL	18.1
111	TBC-18	LEROY	0	722	VHF	96G	220	27APR89	12:00	RETAGGED	10MAY89	11:00	7	REC TX; TETHER CUT; BOAT; 27DEC89 DEAD	13.0
112	TBC-19	SHARON	1	10023	PTT	66Y	230	21APR88	10:25	NET TAG	01MAY88	19:01	2	LAST LOC; 28MAY88 REC PTT; WL (HUMAN)	10.4
113	TBC-20	RUTH	0	705	VHF	90R	215	21APR88	13:48	NET TAG	22APR88	12:00	30	LAST LOC; TX LOST; WL	0.9
114	TBC-20	RUTH	0	780	VHF	90R	210	08JUL88	14:30	RETAGGED SAFETY	12JUL88	18:00	19	REP TX; TO TX	4.1
115	TBC-20	RUTH	0	790	VHF	90R	215	12JUL88	18:00	REP TX	22SEP88	9:15	16	REP TX; TX MALFUNCT (ANT MISSING)	71.6
116	TBC-20	RUTH	0	720	VHF	90R	215	22SEP88	9:15	REP TX	16OCT88	10:30	1	REC TX; WL	24.1
117	TBC-20	RUTH	0	720	VHF	90R	215	25OCT88	11:00	RETAGGED	01DEC88	17:00	20	REP TX; TO PTT	37.3
118	TBC-20	RUTH	1	9992	PTT	90R	215	01DEC88	17:00	REP TX	14DEC88	23:59	30	LAST LOC; PTT LOST; WL	13.3
119	TBC-20	RUTH	0	430	VHF	90R	215	06JAN89	12:16	RETAGGED SAFETY	10JAN89	14:00	6	REC TX; SAFETY SNAP FAIL	4.1
120	TBC-20	RUTH	0	438	VHF	90R	215	24JAN89	17:45	RETAGGED	08JUN89	9:35	30	LAST LOC; TX LOST; WL	134.7
121	TBC-20	RUTH	0	546	VHF	90R	225	13JUN89	17:45	RETAGGED	09AUG89	14:15	20	REP TX; TO PTT	56.9
122	TBC-20	RUTH	2	9990	PTT	90R	225	09AUG89	14:15	REP TX	24AUG89	12:45	17	REP TX; PTT MALFUNCT (VHF OUT)	14.9
123	TBC-20	RUTH	0	730	VHF	90R	225	24AUG89	12:45	REP TX	13SEP89	15:00	20	REP TX; TO PTT	20.1
124	TBC-20	RUTH	3	10023	PTT	90R	225	13SEP89	15:00	REP TX	07JAN90	14:25	18	LAST LOC; 1MAY90 REM PTT; BOAT	116.0
125	TBC-20	RUTH	0	839	VHF	90R	210	01MAY90	19:00	RETAGGED	02MAY90	13:00	25	REP TX BLT; BELT WORN	0.8
126	TBC-20	RUTH	4	9990	PTT	107R	220	02MAY90	13:00	REP TX BLT	23JUL90	14:30	15	REP TX; LOW BATT	82.1
127	TBC-20	RUTH	5	9644	PTT	107R	220	23JUL90	14:30	REP TX	20OCT90	14:43	0	LAST LOC; 21OCT90 REC TX BLT; DEAD	89.0
128	TBC-21	WILLIE	0	521	VHF	3R	215	22APR88	12:52	NET TAG	01SEP88	10:30	20	REP TX; TO PTT	131.9
129	TBC-21	WILLIE	1	10026	PTT	3R	215	01SEP88	10:30	REP TX	09SEP88	23:59	16	LAST LOC; 26NOV88 REC PTT; FLOODED	8.6
130	TBC-21	WILLIE	0	646	VHF	3R	225	13FEB90	17:00	RETAGGED	28FEB90	12:30	20	REP TX; TO PTT	14.8
131	TBC-21	WILLIE	2	9640	PTT	3R	225	28FEB90	12:30	REP TX	06MAR90	10:00	2	LAST LOC; 12DEC90 REM BLT; REC TX; WL	5.9
132	TBC-22	MAGOO	0	696	VHF	98G	203	07JUN88	12:45	CAP REL	17FEB89	12:00	16	REP TX; TX MALFUNCTION (BARNACLES)	255.0
133	TBC-22	MAGOO	0	670	VHF	98G	0	17FEB89	12:00	REP TX	19APR89	15:00	35	LAST LOC; TX MIA	61.1

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Appendix 4a (continued)

	ID	NAME	BOUT	TAGNO	TAG TYPE	BELT	TETHER	ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
134	TBC-23	HILLARY	0	604	VHF	100R	215	07JUN88	12:30	CAP REL	09SEP88	12:00	16	REP TX; TX MALFUNCT (ANT MISSING)	94.0
135	TBC-23	HILLARY	0	800	VHF	100R	215	09SEP88	12:00	REP TX	11NOV88	12:00	16	REP TX; TX MALFUNCT (ANT MISSING)	63.0
136	TBC-23	HILLARY	0	740	VHF	100R	215	11NOV88	12:00	REP TX	18NOV88	12:00	1	REC TX; WL	7.0
137	TBC-23	HILLARY	0	636	VHF	100R	205	25JUL89	12:00	RETAGGED SAFETY	26JUL89	10:15	19	REP TX; TO TX	0.9
138	TBC-23	HILLARY	0	496	VHF	100R	220	26JUL89	10:15	REP TX	14SEP89	17:00	19	REP TX; TO TX	50.3
139	TBC-23	HILLARY	0	730	VHF	100R	220	14SEP89	17:00	REP TX	27SEP89	10:15	20	REP TX; TO PTT	12.7
140	TBC-23	HILLARY	1	9997	PTT	100R	220	27SEP89	10:15	REP TX	02NOV89	14:30	25	REP BLT; BELT WORN	36.2
141	TBC-23	HILLARY	2	9997	PTT	91R	220	02NOV89	14:30	REP BLT	25DEC89	19:46	1	LAST LOC; 27DEC89 REC TX; WL	53.2
142	TBC-23	HILLARY	0	740	VHF	91R	220	19NOV90	16:30	RETAGGED	10APR91	16:05	20	REP TX; TO PTT	142.0
143	TBC-23	HILLARY	3	9999	PTT	91R	220	10APR91	16:05	REP TX	16MAY91	4:30	5	LAST LOC; 27MAY91 REC PTT; SWIVEL FAIL	35.5
144	TBC-23	HILLARY	0	636	VHF	91R	205	30SEP91	11:00	RETAGGED SAFETY	01OCT91	12:30	20	REP TX; TO PTT	1.1
145	TBC-23	HILLARY	4	9997	PTT	91R	225	01OCT91	12:30	REP TX	10MAR92	13:30	15	REP TX; PTT LOW BATT	161.0
146	TBC-23	HILLARY	5	9996	PTT	91R	225	10MAR92	13:30	REP TX	27JUN92	5:00	35	LAST LOC; UNIT SUNK	108.6
147	TBC-23	HILLARY	0	511	VHF	91R	22	29APR94	8:30	RETAGGED SAFETY	29APR94	14:15	20	REP TX; TO PTT	0.2
148	TBC-23	HILLARY	6	9648	PTT	91R	53	29APR94	14:15	REP SAFETY	30APR94	6:00	6	LAST LOC; 4MAY94 REC TX; UNSCREWED	0.7
149	TBC-23	HILLARY	0	511	VHF	91R	.	10APR95	10:00	RETAGGED SAFETY	12APR95	10:50	26	REP TX & BLT; BLT WORN	2.0
150	TBC-23	HILLARY	7	9648	PTT	75Y	50	12APR95	10:50	REP TX BLT	04JUL95	14:29	1	LAST LOC; 5JUL95 REC PTT; WL	83.2
151	TBC-23	HILLARY	0	511	VHF	75Y	.	05JUL95	17:00	RETAGGED	07JUL95	16:30	1	REP TX; TO BETTER UNIT	2.0
152	TBC-23	HILLARY	8	9648	PTT	75Y	.	07JUL95	16:30	REP TX	11AUG95	23:59	6	LAST LOC; 1SEP95 REC PTT; UN-SCREWED	35.3
153	TBC-24	BETTY	0	612	VHF	75Y	220	05APR89	13:00	FREE TAG	06JUN89	13:30	20	REP TX; TO PTT	62.0
154	TBC-24	BETTY	1	9990	PTT	75Y	220	06JUN89	13:30	REP TX	13JUN89	22:00	1	LAST LOC; 15JAN90 REC PTT; WL	7.4
155	TBC-24	BETTY	0	722	VHF	75Y	215	14JUN89	16:00	RETAGGED	15JUN89	15:30	20	REP TX; TO PTT	1.0
156	TBC-24	BETTY	2	9990	PTT	75Y	215	15JUN89	15:30	REP TX	07AUG89	1:00	1	LAST LOC; 8AUG89 REC PTT; WL	52.4
157	TBC-24	BETTY	3	9993	PTT	75Y	220	16NOV89	9:45	RETAGGED	10DEC89	3:45	1	LAST LOC; 12DEC89 REC TX; WL	23.8
158	TBC-24	BETTY	4	9993	PTT	75Y	230	13DEC89	17:00	RETAGGED	25JAN90	6:30	1	LAST LOC; 28JAN90 REC TX; WL	42.6
159	TBC-24	BETTY	0	839	VHF	75Y	215	06FEB90	12:00	RETAGGED	12FEB90	15:30	20	REP TX; TO PTT	6.1
160	TBC-24	BETTY	5	9993	PTT	75Y	215	12FEB90	15:30	REP TX	11JUN90	18:00	15	REP TX; PTT LOW BATT	119.1
161	TBC-24	BETTY	0	790	VHF	75Y	215	11JUN90	18:00	REP TX	20NOV90	17:00	1	REC TX; WL	162.0
162	TBC-24	BETTY	0	100	VHF	75Y	210	21NOV90	15:00	RETAGGED SAFETY	28NOV90	11:30	19	REP TX; TO TX	6.9
163	TBC-24	BETTY	0	445	VHF	75Y	215	28NOV90	11:30	REP TX	08JAN91	16:00	1	REC TX; WL	41.2
164	TBC-24	BETTY	0	445	VHF	75Y	0	09JAN91	11:45	RETAGGED	14MAR91	17:50	20	REP TX; TO PTT	64.3
165	TBC-24	BETTY	6	9644	PTT	75Y	0	14MAR91	17:50	REP TX	29APR91	16:00	1	LAST LOC; 30APR91 REC TX; WL	45.9
166	TBC-24	BETTY	0	100	VHF	75Y	210	19JUN91	9:10	RETAGGED SAFETY	20JUN91	10:30	19	REP TX; TO TX	1.1
167	TBC-24	BETTY	0	780	VHF	75Y	225	20JUN91	10:30	REP TX	17JUL91	9:30	25	REP TX BLT; BELT WORN	27.0

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Appendix 4a (continued)

ID	NAME	BOUT	TAGNO	TAG TYPE	BELT	TETHER	ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
168	TBC-24 BETTY	0	730	VHF	119NR	22	17JUL91	9:30	REP TX BLT	05NOV91	16:00	20	REP TX; TO PTT	111.3
169	TBC-24 BETTY	7	9646	PTT	119NR	22	05NOV91	16:00	REP TX	05MAY92	17:30	20	REP TX; TO PTT	182.1
170	TBC-24 BETTY	8	7343	PTT	119NR	22	05MAY92	17:30	REP TX	05AUG92	14:00	15	REP TX; LOW BATT	91.9
171	TBC-24 BETTY	9	2102	PTT	119NR	22	05AUG92	14:00	REP TX	20NOV92	15:55	15	REP TX; LOW BATT	107.1
172	TBC-24 BETTY	9	9995	PTT	119NR	22	20NOV92	15:55	REP TX	24FEB93	13:45	25	REP TX BLT; BLT WORN	95.9
173	TBC-24 BETTY	10	7348	PTT		225	24FEB93	13:45	REP TX BLT	03JUN93	14:50	15	REP TX; LOW BATT	99.0
174	TBC-24 BETTY	11	2101	PTT		225	03JUN93	14:50	REP TX	06DEC93	13:45	15	REP TX; LOW BATT	186.0
175	TBC-24 BETTY	12	7341	PTT		225	06DEC93	13:45	REP TX	25DEC93	6:00	1	LAST LOC; 29DEC93 REC TX; WL	18.7
176	TBC-24 BETTY	0	720	VHF		22	30DEC93	12:00	RETAGGED SAFETY	06JAN94	11:45	20	REP TX; TO PTT	7.0
177	TBC-24 BETTY	13	7345	PTT		56	06JAN94	11:45	REP TX	11MAY94	10:40	15	REP TX; LOW BATT	125.0
178	TBC-24 BETTY	14	9997	PTT		56	11MAY94	10:40	REP TX	21NOV94	11:15	15	REP TX; LOW BATT	194.0
179	TBC-24 BETTY	15	7348	PTT		56	21NOV94	11:15	REP TX	21APR95	12:05	15	REP BLT & TX; WORN & LOW BATT; NET CAP	151.0
180	TBC-24 BETTY	16	7341	PTT	165Y	53	21APR95	12:05	NET REP TX BLT	16MAY95	4:59	1	LAST LOC; 20MAY95 REC PTT; WL	24.7
181	TBC-25 D-COW	0	730	VHF	101G	200	11APR89	13:35	NET TAG	03AUG89	10:00	1	REC TX; WL	113.9
182	TBC-25 D-COW	0	790	VHF	101G	215	27AUG89	11:30	RETAGGED	31AUG89	12:00	1	REC TX; WL	4.0
183	TBC-25 D-COW	0	612	VHF	101G	205	01SEP89	12:00	RETAGGED	13FEB90	10:00	20	REP TX; TO PTT	164.9
184	TBC-25 D-COW	1	9994	PTT	101G	205	13FEB90	10:00	REP TX	22MAY90	11:45	19	REP TX; TO TX	98.1
185	TBC-25 D-COW	0	839	VHF	101G	205	22MAY90	11:45	REP TX	21NOV90	12:30	10	REC TX BLT; BELT BROKEN	183.0
186	TBC-26 PEEWEE	0	839	VHF	94Y	225	16NOV89	9:20	FREE TAG	18DEC89	11:30	20	REP TX; TO PTT	32.1
187	TBC-26 PEEWEE	1	9995	PTT	94Y	225	18DEC89	11:30	REP TX	21MAY90	14:30	16	REP TX; PTT MALFUNCT (ANT MISSING)	154.1
188	TBC-26 PEEWEE	2	9996	PTT	94Y	225	21MAY90	14:30	REP TX	16AUG90	9:12	1	LAST LOC; 19AUG90 REC TX; WL	86.8
189	TBC-26 PEEWEE	3	9999	PTT	94Y	240	27SEP90	11:00	RETAGGED	29MAR91	10:30	5	LAST LOC; 29MAR91 REC TX; SWIVEL FAIL	183.0
190	TBC-26 PEEWEE	0	530	VHF	121Y	225	29MAY91	17:00	REP TX & BLT	28NOV91	12:00	20	REP TX; TO PTT	182.8
191	TBC-26 PEEWEE	4	9648	PTT	212Y	225	28NOV91	12:00	REP TX	06JAN92	12:00	1	LAST LOC; 06JAN92 REC PTT; WL	39.0
192	TBC-26 PEEWEE	0	720	VHF	212Y	225	30JAN92	12:00	RETAGGED SAFETY	02FEB92	12:00	20	REP TX; TO PTT	3.0
193	TBC-26 PEEWEE	5	7339	PTT	212Y	225	02FEB92	12:00	REP TX	16JUN92	12:00	1	LAST LOC; 23JUN92 REC TX; WL	135.0
194	TBC-26 PEEWEE	6	7345	PTT	212Y	47	06MAY93	11:35	RETAGGED	16JUL93	6:00	1	LAST LOC; 16JUL93 REC TX; WL	70.8
195	TBC-26 PEEWEE	0	496	VHF	212Y	22	29DEC93	13:00	RETAGGED SAFETY	06JAN94	15:40	20	REP TX; TO PTT	8.1
196	TBC-26 PEEWEE	7	7341	PTT	212Y	53	06JAN94	15:40	REP TX	09MAY94	6:00	1	LAST LOC; 11MAY94 REC TX; WL	122.6
197	TBC-26 PEEWEE	8	7347	PTT	212Y	22	20JUN94	11:30	RETAGGED	16JUL94	10:00	6	LAST LOC; 17JUL94 REC TX; UNSCREWED	25.9
198	TBC-26 PEEWEE	0	496	VHF	212Y	22	16JUL94	10:00	RETAGGED SAFETY	22SEP94	12:00	1	LAST LOC; 12JAN95 REC TX; WL	68.1
199	TBC-27 MEL	0	530	VHF	89G	200	02MAY90	10:00	CAP REL	30APR91	17:00	16	REP TX; TX MALFUNCT (BARNACLES)	363.3
200	TBC-27 MEL	0	810	VHF	89G	200	30APR91	17:00	REP TX	10AUG91	12:00	1	REC TX; WL	101.8
201	TBC-27 MEL	0	780	VHF	89G	215	13AUG91	14:45	RETAGGED	17OCT91	12:00	18	LAST LOC; 10JAN92 REP TX; BOAT & SUNK	64.9

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Appendix 4a (continued)

ID	NAME	BOUT	TAGNO	TAG TYPE	TETHER BELT	ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
202	TBC-27 MEL	0	496	VHF	89G	0	08JAN92	12:00	RETAGGED	10JAN92	11:15	19	REP TX; TO BETTER UNIT	2.0
203	TBC-27 MEL	0	673	VHF	89G	0	10JAN92	11:15	REP TX	09APR92	12:00	1	REC TX; WL	90.0
204	TBC-28 LIBERTY	0	646	VHF	73R	205	02MAY90	10:00	CAP REL	07OCT90	12:00	1	LAST LOC; 7OCT90 REC TX; WL	158.1
205	TBC-29 CASEY	0	445	VHF	72G	200	21AUG90	9:20	CAP REL	22SEP90	12:00	1	REC TX; WL	32.1
206	TBC-29 CASEY	0	546	VHF	72G	205	25OCT90	17:15	RETAGGED	05JUN91	17:30	16	REP TX; TX MALFUNCT (BARNACLES)	223.0
207	TBC-29 CASEY	0	740	VHF	72G	0	05JUN91	17:30	REP TX	09JUN91	12:00	1	LAST LOC; 11JUN91 REC TX; WL	3.8
208	TBC-29 CASEY	0	780	VHF	72G	225	19JUN91	9:30	RETAGGED	20JUN91	10:00	19	REP TX; TO NEW TETHER	1.0
209	TBC-29 CASEY	0	470	VHF	72G	215	20JUN91	10:00	REP TX	06AUG91	13:50	16	REP TX; TX MALFUNCT (ANT MISSING)	47.2
210	TBC-29 CASEY	0	546	VHF	72G	215	06AUG91	13:50	REP TX	11AUG91	12:00	1	REC TX; WL	4.9
211	TBC-29 CASEY	0	496	VHF	72G	208	16AUG91	14:00	RETAGGED	21AUG91	16:50	19	REP TX; TO NEW TX	5.1
212	TBC-29 CASEY	0	546	VHF	72G	208	21AUG91	16:50	REP TX	22AUG91	12:00	30	LAST LOC; TX LOST; WL	0.8
213	TBC-29 CASEY	0	740	VHF	72G	0	31AUG91	14:00	RETAGGED	19NOV91	17:35	19	REP TX; TO NEW TX	80.1
214	TBC-29 CASEY	0	673	VHF	72G	0	19NOV91	17:35	REP TX	22DEC91	12:00	10	REC TX BLT; BELT BROKEN; BOAT	32.8
215	TBC-30 MARIA	0	355	VHF	106R	220	30OCT90	7:40	NET TAG	26FEB91	17:00	35	LAST LOC; TX MIA	119.4
216	TBC-31 FREDDIE	0	780	VHF	114Y	235	31OCT90	9:30	NET TAG	30APR91	14:30	20	REP TX; TO PTT	181.2
217	TBC-31 FREDDIE	1	9993	PTT	114Y	235	30APR91	14:30	REP TX	27MAY91	8:00	18	LAST LOC; 16JUL91 REC PTT; BOAT & SUNK	26.7
218	TBC-31 FREDDIE	2	9990	PTT	114Y	235	16JUL91	13:30	REP TX	31DEC91	10:00	15	REP TX; LOW BATT	167.9
219	TBC-31 FREDDIE	3	9994	PTT	114Y	235	31DEC91	10:00	REP TX	08APR92	18:20	16	REP TX; PTT BAD FLOAT	99.3
220	TBC-31 FREDDIE	4	7343	PTT	114Y	235	08APR92	18:20	REP TX	24APR92	4:54	1	LAST LOC; 30APR92 REC TX; WL	15.4
221	TBC-32 TOMASINA	0	780	VHF	105B	260	22MAY91	13:45	FREE TAG	07JUN91	12:30	20	REP TX; TO PTT	15.9
222	TBC-32 TOMASINA	1	9641	PTT	105B	260	07JUN91	12:30	REP TX	18JUL91	21:00	1	LAST LOC; 22JUL91 REC PTT; WL	41.4
223	TBC-32 TOMASINA	0	810	VHF	105B	208	30DEC91	12:15	RETAGGED	11FEB92	12:00	35	LAST LOC; TX MIA	43.0
224	TBC-32 TOMASINA	0	740	VHF	105B	225	04MAR93	14:45	RETAGGED	12MAR93	12:00	35	LAST LOC; TX MIA	7.9
225	TBC-32 TOMASINA	0	100	VHF	105B	50	20APR93	12:30	RETAGGED	04MAY93	10:30	20	REP TX; TO PTT	13.9
226	TBC-32 TOMASINA	2	7346	PTT	105B	53	04MAY93	10:30	REP TX	31JUL93	6:00	1	LAST LOC; 31JUL93 REC TX; WL	87.8
227	TBC-32 TOMASINA	0	466	VHF	105B	22	10AUG94	12:00	RETAGGED SAFETY	25AUG94	15:00	26	REM TX BLT	15.1
228	TBC-33 ERNIE	0	646	VHF	122NR	220	06JUN91	12:20	CAP REL	17AUG91	15:00	0	REC TX BLT; DEAD	72.1
229	TBC-34 MILEY	0	590	VHF	120NG	215	15JUL91	10:30	CAP REL	18FEB92	12:00	19	REP TX; TO NEW TX	218.1
230	TBC-34 MILEY	0	466	VHF	120NG	215	18FEB92	12:00	REP TX	10JUN92	10:00	3	REC TX; WL (ALLIGATOR)	112.9
231	TBC-35 E-COW	0	519	VHF	56G	205	05MAY92	15:25	NET TAG	20OCT92	16:43	20	REP TX; TO PTT	168.1
232	TBC-35 E-COW	1	9993	PTT	56G	205	20OCT92	16:43	REP TX	06DEC92	4:00	7	LAST LOC; BOAT	46.5
233	TBC-35 E-COW	0	673	VHF	56G	0	10FEB93	12:00	RETAGGED	10FEB93	16:00	6	REC TX; CON UNSCREWED	0.2
234	TBC-35 E-COW	0	445	VHF	56G	0	16FEB93	16:30	RETAGGED	25FEB93	14:30	20	REP TX; TO PTT	8.9
235	TBC-35 E-COW	2	7345	PTT	56G	210	25FEB93	14:30	REP TX	26FEB93	6:00	6	LAST LOC; 27FEB93 REC TX; CONN UNSCREWED	0.6

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Appendix 4a (continued)

	ID	NAME	BOUT	TAGNO	TAG TYPE	BELT	TETHER	ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
236	TBC-36	SUNSHINE	0	673	VHF	141FY	240	15MAY92	10:30	FREE TAG	10JUN92	17:30	20	REP TX; TO PTT	26.3
237	TBC-36	SUNSHINE	1	4024	PTT	141FY	240	10JUN92	17:30	REP TX	18DEC92	14:45	15	REP TX; LOW BATT	190.9
238	TBC-36	SUNSHINE	2	2102	PTT	141FY	240	18DEC92	14:45	REP TX	01JUN93	19:00	15	REP TX; LOW BATT	165.2
239	TBC-36	SUNSHINE	3	7347	PTT	141FY	240	01JUN93	19:00	REP TX	16SEP93	11:00	1	LAST LOC; 16SEP93 REC TX; WL	106.7
240	TBC-36	SUNSHINE	4	20202	PTT	141FY	53	13JAN94	11:00	RETAGGED	05MAR94	20:00	1	LAST LOC; 7MAR94 REC TX; WL	51.4
241	TBC-37	PAMELA	1	9648	PTT	144FR	230	28MAY92	14:20	CAP REL	13DEC92	9:45	15	REP TX; LOW BATT	198.8
242	TBC-37	PAMELA	2	7346	PTT	144FR	230	13DEC92	9:45	REP TX	09APR93	6:00	1	LAST LOC; 9APR93 REC TX; WL	116.8
243	TBC-38	ADAIR	1	9646	PTT	138FY	245	28MAY92	14:50	CAP REL	11AUG92	17:00	7	LAST LOC; 11AUG92 REC TX; BOAT	75.1
244	TBC-38	ADAIR	2	7349	PTT	138FY	240	17AUG92	17:30	RETAGGED	19NOV92	13:35	15	REP TX; LOW BATT	93.8
245	TBC-38	ADAIR	3	9997	PTT	138FY	240	19NOV92	13:35	REP TX	28DEC92	12:00	40	LAST LOC; 12JAN93 RESCUE	38.9
246	TBC-38	ADAIR	4	7345	PTT		0	07APR93	13:30	CAP REL	12APR93	21:00	1	LAST LOC; 13APR93 REC TX; WL	5.3
247	TBC-38	ADAIR	0	720	VHF	138FY	22	29JAN96	13:30	RETAGGED SAFETY	31JAN96	12:25	20	REP TX; TO PTT	2.0
248	TBC-38	ADAIR	5	9999	PTT	138FY	22	31JAN96	12:25	REP TX	14FEB96	10:15	19	REP TX BLT; BELT WORN	13.9
249	TBC-38	ADAIR	5	9997	PTT	109Y	53	14FEB96	10:15	REP TX BLT	27APR96	14:15	40	REC TX BLT; RESCUE Tm	73.2
250	TBC-39	LYDIA	0	511	VHF	148FG	205	28MAY92	14:50	CAP REL	08OCT92	15:45	1	LAST LOC; 10NOV92 REC TX; WL	133.0
251	TBC-39	LYDIA	0	637	VHF	148FG	220	21OCT92	11:10	RETAGGED	28DEC92	12:00	40	LAST LOC; 12JAN93 RESCUE	68.0
252	TBC-39	LYDIA	0	519	VHF		0	07APR93	13:30	CAP REL	13APR93	9:00	10	REC TX BLT; BELT BROKEN	5.8
253	TBC-40	DANISE	1	7347	PTT	160FR	50	08JUN94	11:16	CAP REL	10JUN94	10:00	1	LAST LOC; 12JUN94 REC TX; WL	1.9
254	TBC-41	SCOTT	1	7340	PTT	182Y	56	01SEP94	9:29	CAP REL	08FEB95	20:42	1	LAST LOC;10FEB95 REC TX; WL	160.5
255	TBC-42	CHESSIE	1	9995	PTT	181Y	56	07OCT94	11:00	CAP REL	17OCT94	17:00	1	LAST LOC; 18OCT94 REC TX; WL	10.3
256	TBC-42	CHESSIE	2	9995	PTT	181Y	60	12JAN95	12:10	RETAGGED	17JUL95	18:00	15	REP TX; LOW BATT	186.2
257	TBC-42	CHESSIE	3	20205	PTT	181Y	60	17JUL95	18:00	REP TX	22AUG95	15:06	1	LAST LOC; 23AUG95 REC TX; WL	35.9
258	TBC-42	CHESSIE	0	466	VHF	181Y	22	20FEB96	10:00	RETAGGED SAFETY	21FEB96	15:45	20	REP TX; TO PTT	1.2
259	TBC-42	CHESSIE	4	9999	PTT	181Y	47	21FEB96	15:45	REP TX	06JUN96	17:13	15	REP TX; LOW BATT	100.3
260	TBC-43	ROBBIE	0	696	VHF	177G	38	21APR95	12:05	NET CAPTURE	28JUN95	10:40	20	REP TX; TO PTT	67.9
261	TBC-43	ROBBIE	1	9997	PTT	177G	38	28JUN95	10:40	REP TX	13JUL95	10:39	1	LAST LOC; 16JUL95 REC TX; WL	15.0
262	TBC-44	MOOSE	1	4027	PTT	171Y	50	01JUN95	16:16	CAP REL	13JUL95	7:00	19	REM TX; TO VHF WHILE IN PENS	41.6
263	TBC-44	MOOSE	2	10027	PTT	171Y	50	19JUL95	13:39	RETAGGING	30NOV95	8:29	0	LAST LOC; 18JAN96 REC Tm; DEAD	133.8
264	TBC-45	HARVEY	1	2104	PTT	136FR	50	25AUG95	14:30	CAP REL	15FEB96	9:45	19	REP TX; LOW BATT	173.8
265	TBC-45	HARVEY	2	4027	PTT	136FR	50	15FEB96	9:45	REP TX	16FEB96	12:30	40	REC TX BLT; RESCUE Tm	1.1
266	TBC-46	FOSTER	1	7345	PTT	113Y	50	26AUG95	8:00	CAP REL	03JAN96	13:00	40	LAST LOC; 4JAN96 RESCUE Tm	130.2
267	TBC-47	INDY	1	9995	PTT	148FR	50	26AUG95	8:00	CAP REL	11NOV95	19:30	0	LAST LOC; 18NOV95 REC BLT TX; DEAD	77.5
268	TFK-01	MANNY	1	9644	PTT	161FY	50	21SEP93	14:50	CAP REL	24MAR94	14:15	15	REP TX; LOW BATT	184.0
269	TFK-01	MANNY	2	2101	PTT	161FY	50	24MAR94	14:15	REP TX	08APR94	11:00	35	LAST LOC; TX MIA	14.9

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Appendix 4a (continued)

	ID	NAME	BOUT	TAGNO	TAG TYPE	BELT	TETHER	ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
270	TFK-01	MANNY	3	9649	PTT	161FY	53	16APR94	15:00	RETAGGED	03MAY94	11:40	26	REM TX BLT	16.9
271	TFK-02	OLLIE	1	9995	PTT	160FR	50	19OCT93	16:55	FREE TAG	15FEB94	20:00	6	LAST LOC; 16FEB94 REC BLT TX; BLT CUT	119.1
272	TFK-03	STAN	1	9990	PTT	57R	53	19OCT93	16:20	FREE TAG	01DEC93	6:00	1	LAST LOC; 4DEC93 REC TX; WL	42.6
273	TFK-03	STAN	0	466	VHF	57R	22	03DEC93	15:00	RETAGGED SAFETY	09DEC93	12:20	20	REP TX; SAFETY TO PTT	5.9
274	TFK-03	STAN	2	9990	PTT	57R	53	09DEC93	12:20	REP TX SAFETY	08FEB94	10:00	1	LAST LOC; 16FEB94 REC TX; WL	60.9
275	TFK-03	STAN	0	466	VHF	57R	22	27FEB94	14:30	RETAGGED SAFETY	02MAR94	13:15	20	REP TX; SAFETY TO PTT	2.9
276	TFK-03	STAN	3	9649	PTT	57R	53	02MAR94	13:15	REP TX SAFETY	30MAR94	21:00	1	LAST LOC; 31MAR94 REC TX; WL	28.3
277	TFK-03	STAN	0	720	VHF	57R	22	01MAY94	15:30	RETAGGED SAFETY	24MAY94	15:45	26	REM TX BLT	23.0
278	TFP-01	HUTCH	1	9643	PTT	110R	235	10APR90	10:05	CAP REL	21APR90	14:00	35	LAST LOC; PTT MIA	11.2
279	TFP-02	ROSS	1	9990	PTT	111R	250	07NOV90	15:00	CAP REL	24MAY91	16:45	15	REP TX; LOW BATT	198.1
280	TFP-02	ROSS	2	9644	PTT	111Y	250	24MAY91	16:45	REP TX	07AUG91	17:30	25	REP TX BLT; BELT WORN	75.0
281	TFP-02	ROSS	3	9995	PTT	126NY	250	07AUG91	17:30	REP TX & BLT	08AUG91	19:00	19	REP TX; TO BEST PTT	1.1
282	TFP-02	ROSS	4	9644	PTT	126NY	250	08AUG91	19:00	REP TX	25SEP91	11:45	15	REP TX; PTT LOW BATT	47.7
283	TFP-02	ROSS	5	9999	PTT	126NY	250	25SEP91	11:45	REP TX	16MAR92	16:00	15	REP TX; PTT LOW BATT	173.2
284	TFP-02	ROSS	6	9993	PTT	126NY	250	16MAR92	16:00	REP TX	07JUL92	11:30	17	REP TX; MALFUNCT	112.8
285	TFP-02	ROSS	7	7345	PTT	126NY	250	07JUL92	11:30	REP TX	14DEC92	17:00	15	REP TX; LOW BATT	160.2
286	TFP-02	ROSS	8	9645	PTT	126NY	250	14DEC92	17:00	REP TX	16JUN93	19:00	16	REP TX; TX MALFUNCT (ANT MISSING)	184.1
287	TFP-02	ROSS	9	4026	PTT	126NY	250	16JUN93	19:00	REP TX	18JUL93	3:45	1	LAST LOC; TX LOST; WL	31.4
288	TFP-02	ROSS	10	4024	PTT	126NY	.	08AUG93	13:35	RETAGGED SAFETY	20OCT93	5:00	1	LAST LOC; 4NOV93 REC TX; WL	72.6
289	TFP-02	ROSS	11	9649	PTT	126NY	22	16JUN94	13:30	RETAGGED SAFETY	25OCT94	11:20	15	REP TX; LOW BATT	130.9
290	TFP-02	ROSS	12	7348	PTT	126NY	22	25OCT94	11:20	REP TX	25OCT94	21:28	0	LAST LOC; 26OCT94 REC TX BLT; DEAD	0.4
291	TFP-03	NATALIE	1	9994	PTT	128NP	22	24JUL91	10:00	CAP REL	07NOV91	3:28	17	LAST LOC; BATT FAIL	105.7
292	TFP-03	NATALIE	2	9647	PTT	128NP	22	27NOV91	11:30	RETAGGED	27NOV91	16:00	1	LAST LOC; 27NOV91 REC TX; WL	0.2
293	TFP-03	NATALIE	0	470	VHF	128NP	240	07FEB92	11:30	RETAGGED	13FEB92	16:30	20	REP TX; TO PTT	6.2
294	TFP-03	NATALIE	3	7343	PTT	128NP	240	13FEB92	16:30	REP TX	05MAR92	19:46	1	LAST LOC; 06MAR92 REC TX; WL	21.1
295	TFP-03	NATALIE	4	2102	PTT	128NP	245	04DEC92	11:00	RETAGGED	14DEC92	19:00	1	LAST LOC; 15DEC92 REC TX; WL	10.3
296	TFP-03	NATALIE	5	9645	PTT	136FP	47	17DEC93	12:00	RETAGGED TX BLT	17DEC93	22:00	1	LAST LOC; 18DEC93 REC TX; WL	0.4
297	TFP-03	NATALIE	6	20203	PTT	136FP	56	19JAN94	12:30	RETAGGED	26SEP94	13:15	26	REM TX BLT	250.0
298	TFP-04	SOPHIA	1	9641	PTT	133NR	250	26JUL91	13:15	FREE TAG	16SEP91	14:42	35	LAST LOC; REC TX XXXXXXX UNIT SUNK	52.1
299	TFP-04	SOPHIA	2	7340	PTT	133NR	250	16FEB92	13:30	REP TX - SUNK	15MAR92	19:28	4	LAST LOC; 16MAR92 REC TX; EYEBOLT BROKEN	28.2
300	TFP-04	SOPHIA	0	673	VHF	133NR	225	11JUN92	15:00	RETAGGED	02JUL92	15:15	20	REP TX; TO PTT	21.0
301	TFP-04	SOPHIA	3	7345	PTT	133NR	225	02JUL92	15:15	REP TX	04JUL92	10:00	1	LAST LOC; WL	1.8
302	TFP-04	SOPHIA	8	10027	PTT	123NP	53	16DEC93	10:45	RETAGGED	16JUN94	11:45	15	REP TX; LOW BATT	182.0
303	TFP-04	SOPHIA	9	7344	PTT	123NP	53	16JUN94	11:45	REP TX	22AUG94	5:48	35	LAST LOC; TX MIA	66.8

(Appendix 4a continued on next page)

Appendix 4a (continued)

					TAG		TETHER								
	ID	NAME	BOUT	TAGNO	TYPE	BELT		ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
304	TFP-04	SOPHIA	0	999	VHF	123NP	53	06FEB95	12:00	RETAGGED	09FEB95	13:45	20	REP TX; TO PTT	3.1
305	TFP-04	SOPHIA	10	4024	PTT	123NP	53	09FEB95	13:45	REP TX	17MAR95	9:44	1	LAST LOC; 4APR95 REC TX; WL	35.8
306	TFP-04	SOPHIA	11	20203	PTT	123NP	.	08JAN96	12:20	RETAGGED	24MAR96	15:15	10	LAST LOC; 27MAR96 REC TX BLT; BELT WORN	76.1
307	TFP-05	LANI	1	9995	PTT	130NB	250	10AUG91	11:00	FREE TAG	24SEP91	9:25	1	LAST LOC; 26SEP91 REC PTT; WL	44.9
308	TFP-05	LANI	2	9995	PTT	130NB	245	26SEP91	16:30	RETAGGED	11FEB92	11:15	15	REP TX	137.8
309	TFP-05	LANI	3	9648	PTT	130NB	245	11FEB92	11:15	REP TX	06APR92	5:08	1	LAST LOC; 06APR92 REC TX; WL	54.7
310	TFP-05	LANI	0	720	VHF	130NB	0	04DEC92	12:00	RETAGGED	10DEC92	12:00	6	REC TX; SAFETY FAIL	6.0
311	TFP-05	LANI	4	7348	PTT	130NB	245	15DEC92	17:00	RETAGGED	01FEB93	9:00	1	LAST LOC; 5FEB93 REC PTT; WL	47.7
312	TFP-05	LANI	5	9647	PTT	130NB	225	01MAR93	10:00	RETAGGED	16MAR93	6:00	35	LAST LOC; TX MIA; BELT OFF	14.8
313	TFP-06	VANNA	1	7340	PTT	137FR	260	20MAR92	11:45	FREE TAG	22JUL92	13:15	15	REP TX; LOW BATT	124.1
314	TFP-06	VANNA	2	9999	PTT	137FR	260	22JUL92	13:15	REP TX	03DEC92	17:15	16	REP TX; MALFUNCT (BROKEN ANT)	134.2
315	TFP-06	VANNA	3	9647	PTT	137FR	260	03DEC92	17:15	REP TX	20FEB93	9:30	6	LAST LOC; 20FEB93 REC TX; WL	78.7
316	TFP-06	VANNA	0	740	VHF	137FR	0	20FEB93	10:15	RETAGGED	24FEB93	17:00	20	REP TX; TO PTT	4.3
317	TFP-06	VANNA	4	9997	PTT	137FR	50	24FEB93	17:00	REP TX	02JUL93	10:00	1	LAST LOC; 3JUL93 REC TX; WL	127.7
318	TFP-06	VANNA	5	7339	PTT	137FR	56	18DEC93	12:00	RETAGGED	25MAY94	9:00	15	REP TX; LOW BATT	157.9
319	TFP-06	VANNA	6	9648	PTT	137FR	56	25MAY94	9:00	REP TX	15AUG94	6:00	1	LAST LOC; 25AUG94 REC TX; WL	81.9
320	TFP-06	VANNA	0	790	VHF	137FR	.	26JAN95	12:00	RETAGGED	23MAR95	15:30	26	REM TX & BLT; BLT WORN	56.1
321	TGA-01	MARY	0	720	VHF	31P	235	26JUL89	11:00	FREE TAG	06SEP89	16:30	20	REP TX; TO PTT	42.2
322	TGA-01	MARY	1	9996	PTT	31P	235	06SEP89	16:30	REP TX	13MAR90	17:45	15	REP TX; PTT LOW BATT	188.1
323	TGA-01	MARY	2	9642	PTT	31P	235	13MAR90	17:45	REP TX	29APR90	4:55	0	LAST LOC; 07MAY90 REC BLT; DEAD	46.5
324	TGA-02	TORY	1	20211	PTT	168FR	60	10MAR95	10:20	NET TAG	23AUG95	15:15	35	LAST LOC; PTT MIA	166.2
325	TGA-03	MARMONTEL	1	20209	PTT	167Y	60	10MAR95	10:50	NET TAG	13OCT95	19:00	16	LAST LOC; 17OCT95 REM PTT; UNIT SUNK	217.3
326	TGA-03	MARMONTEL	0	511	VHF	167Y	60	13OCT95	19:00	REP TX	17OCT95	13:16	20	REP TX; TO PTT	3.8
327	TGA-03	MARMONTEL	2	7348	PTT	167Y	60	17OCT95	13:16	REP TX	13JAN96	14:45	18	LAST LOC; 13MAR96 REC TX BLT; BOAT SUNK	88.1
328	TGA-03	MARMONTEL	3	20212	PTT	192Y	53	13MAR96	9:04	NET TAG	31DEC99	23:59	99	ON	79.6
329	TGA-04	MERCURY	1	20209	PTT	149FB	56	12MAR96	8:30	NET TAG	31DEC99	23:59	99	ON	80.6
330	TJX-01	CONNIE	1	9996	PTT	47R	225	11SEP90	10:35	CAP REL	13NOV90	21:00	17	LAST LOC; BATT FAIL	63.4
331	TJX-01	CONNIE	0	790	VHF	47R	225	09DEC90	17:00	REP TX	27MAR91	9:00	20	REP TX; TO PTT	107.7
332	TJX-01	CONNIE	2	9996	PTT	47R	225	27MAR91	9:00	REP TX	30APR91	9:00	1	LAST LOC; 30APR91 REC PTT; WL	34.0
333	TJX-01	CONNIE	0	616	VHF	47R	230	19JAN92	15:00	RETAGGED SAFETY	12FEB92	15:00	20	REP TX; TO PTT	24.0
334	TJX-01	CONNIE	3	7342	PTT	47R	230	12FEB92	15:00	REP TX	15JUN92	12:00	5	LAST LOC; REC TX BLT 15JUN92; BLT CORROD	123.9
335	TJX-02	PATIENCE	1	9996	PTT	118Y	235	02MAY91	16:00	CAP REL	13AUG91	10:05	17	REP TX; BATT FAIL	102.8
336	TJX-02	PATIENCE	2	9645	PTT	118Y	235	13AUG91	10:05	REP TX	10FEB92	3:35	1	LAST LOC; 10FEB92 REC TX; WL	180.7
337	TJX-02	PATIENCE	3	4027	PTT	118Y	53	06FEB95	13:00	RETAGGED	01MAY95	13:52	0	REC TX BLT; DEAD	84.0

(Appendix 4a continued on next page)

Appendix 4a (continued)

	ID	NAME	BOUT	TAGNO	TAG TYPE	TETHER BELT		ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
338	TJX-03	FRECKLES	0	673	VHF	149FG	44	19OCT93	13:20	CAP REL	29OCT93	16:15	20	REP TX; TO PTT	10.1
339	TJX-03	FRECKLES	1	7346	PTT	149FG	44	29OCT93	16:15	REP TX	28APR94	12:03	15	REP TX; LOW BATT	180.8
340	TJX-03	FRECKLES	2	2104	PTT	149FG	44	28APR94	12:03	REP TX	23MAY94	6:00	10	LAST LOC; 24MAY94 REC TX BLT; BLT BROKEN	24.7
341	TMI-01	BOB	0	646	VHF	57Y	250	10DEC90	14:30	CAP REL	24JAN91	10:15	20	REP TX; TO PTT	44.8
342	TMI-01	BOB	1	9644	PTT	57Y	250	24JAN91	10:15	REP TX	07MAR91	21:00	1	LAST LOC; 12MAR91 REC PTT; WL	42.4
343	TMI-01	BOB	2	7339	PTT	140FY	22	23JUL92	14:30	RETAGGED TX BLT	31AUG92	20:00	1	LAST LOC; WL	39.2
344	TMI-01	BOB	0	720	VHF	140FY	0	10FEB93	11:00	RETAGGED	12FEB93	16:30	20	REP TX; TO PTT	2.2
345	TMI-01	BOB	3	4024	PTT	140FY	56	12FEB93	16:30	REP TX	16JUN93	9:30	15	REP TX; LOW BATT	123.7
346	TMI-01	BOB	4	2102	PTT	140FY	56	16JUN93	9:30	REP TX	25JAN94	13:50	15	REP TX; LOW BATT	223.2
347	TMI-01	BOB	5	7349	PTT	140FY	56	25JAN94	13:50	REP TX	22MAR94	15:50	17	REP TX; MALFUNCT (ELECTRICAL)	56.1
348	TMI-01	BOB	6	7347	PTT	140FY	56	22MAR94	15:50	REP TX	30MAY94	10:00	1	LAST LOC; 30MAY94 REC TX; WL	68.8
349	TMI-02	FERGIE	1	7342	PTT	142FR	230	02SEP92	13:58	NET TAG	11MAR93	16:50	15	REP TX; LOW BATT	190.1
350	TMI-02	FERGIE	2	7343	PTT	142FR	230	11MAR93	16:50	REP TX	21OCT93	12:18	15	REP TX; LOW BATT	223.8
351	TMI-02	FERGIE	3	9648	PTT	142FR	230	21OCT93	12:18	REP TX	04DEC93	10:00	1	LAST LOC; 5DEC93 REC TX; WL	43.9
352	TMI-03	CLOCKWORK	1	9993	PTT	149FB	53	11FEB94	14:00	FREE TAG	22AUG94	6:00	10	LAST LOC; 26AUG94 REC BLT TX; BLT BROKEN	191.7
353	TNC-01	DIANE	0	659	VHF	42P	215	11MAR87	11:20	NET TAG	19NOV87	10:30	20	REP TX; TO PTT	253.0
354	TNC-01	DIANE	1	10026	PTT	42P	215	19NOV87	10:30	REP TX	26JUL88	13:15	15	REP TX; LOW BATT	250.1
355	TNC-01	DIANE	2	10024	PTT	42P	215	26JUL88	13:15	REP TX	19AUG88	16:54	30	LAST LOC; PTT LOST; WL	24.2
356	TNC-01	DIANE	3	9990	PTT	42P	220	18DEC89	14:20	RETAGGED	02APR90	11:30	16	REP TX; PTT MALFUNCT (ALGAE ON ANT)	104.9
357	TNC-01	DIANE	4	9643	PTT	42P	220	02APR90	11:30	REP TX	04APR90	6:00	1	LAST LOC; 6APR90 REC PTT; WL	1.8
358	TNC-01	DIANE	5	9645	PTT	42P	245	21FEB91	14:15	RETAGGED	05JUN91	15:15	25	REP TX BLT; BELT WORN	104.0
359	TNC-01	DIANE	6	9990	PTT	123NP	240	05JUN91	15:15	REP TX BLT	12JUN91	4:24	1	LAST LOC; ????? REC PTT; WL	6.5
360	TNC-01	DIANE	7	9999	PTT	123NP	230	13AUG91	15:45	RETAGGED	23AUG91	16:00	1	LAST LOC; REC PTT; WL	10.0
361	TNC-02	JESSE	0	584	VHF	76Y	215	11MAR87	1:13	NET TAG	02MAY87	12:00	35	LAST LOC; TX MIA	52.4
362	TNC-03	TAMMY	0	780	VHF	27p	225	25FEB88	8:44	NET TAG	12MAY88	12:00	2	REC TX; WL (HUMAN)	77.1
363	TNC-03	TAMMY	1	20210	PTT	139FP	60	12MAR96	8:30	NET TAG	10MAY96	16:05	1	1AST LOC; 12MAY96 REC TX; WL	59.3
364	TNC-04	PAT	0	850	VHF	83Y	215	25FEB88	9:34	NET TAG	21APR88	12:00	35	LAST LOC; TX MIA	56.1
365	TNC-05	ROSEANNE	0	790	VHF	91B	235	18JAN89	11:43	NET TAG	31MAY89	12:00	10	REC TX BLT; BELT BROKEN (CAVORTING)	133.0
366	TNC-06	NANCY	0	713	VHF	87R	210	18JAN89	12:53	NET TAG	09APR89	12:00	30	LAST LOC; LOST TX; WL	81.0
367	TNC-06	NANCY	0	470	VHF	87R	215	18FEB91	14:00	RETAGGED	31MAY91	10:35	20	REP TX; TO PTT	101.9
368	TNC-06	NANCY	1	9999	PTT	87R	215	31MAY91	10:35	REP TX	05JUN91	4:06	1	LAST LOC; 8JUN91 REC PTT; WL	4.7
369	TNC-07	WHITIE	0	470	VHF	92R	210	16MAR89	9:20	NET TAG	01AUG89	12:00	1	LAST LOC; 14AUG89 REC TX; WL	138.1
370	TNC-08	GEORGE	0	604	VHF	95R	215	16MAR89	9:46	NET TAG	16MAY89	12:00	35	LAST LOC; TX MIA	61.1
371	TNC-09	JANATEE	1	20210	PTT	137FG	53	12MAR95	10:10	NET TAG	19SEP95	10:09	1	LAST LOC; 26AUG95 REC PTT; WL	191.0

(Appendix 4a continued on next page)

Appendix 4a (continued)

	ID	NAME	BOUT	TAGNO	TAG TYPE	BELT	TETHER	ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
372	TNC-10	MARCH	1	20212	PTT	166P	60	12MAR95	11:15	NET TAG	11OCT95	16:10	15	REP TX; LOW BATT	213.2
373	TNC-10	MARCH	2	20205	PTT	166P	60	11OCT95	16:10	REP TX	21JAN96	10:00	7	LAST LOC; PTT LOST; BOAT STRIKE	101.7
374	TNC-10	MARCH	3	27221	PTT	166P	56	13MAR96	8:11	NET TAG	31DEC99	23:59	99	ON	79.7
375	TNC-11	VALE	1	10027	PTT	178G	50	12MAR95	11:33	NET TAG	30APR95	11:30	1	LAST LOC; 30APR95 REC PTT; WL	49.0
376	TNC-12	MOSSIE	1	27222	PTT	193Y	53	13MAR96	10:20	NET TAG	31DEC99	23:59	99	ON	79.6
377	TPE-01	SPOT	0	496	VHF	94Y	220	27JAN89	15:45	FREE TAG	10FEB89	12:00	20	REP TX; TO PTT	13.8
378	TPE-01	SPOT	1	9994	PTT	94Y	220	10FEB89	12:00	REP TX	26MAR89	1:00	10	LAST LOC; 26MAR REC TX & BLT	43.5
379	TPE-01	SPOT	0	546	VHF	94Y	215	19DEC89	14:20	RETAGGED	12JAN90	16:30	20	REP TX; TO PTT	24.1
380	TPE-01	SPOT	2	9641	PTT	94Y	215	12JAN90	16:30	REP TX	26APR90	19:27	17	LAST LOC; 1MAY90 REP PTT; BATT FAIL	104.1
381	TPE-01	SPOT	3	9644	PTT	95Y	215	01MAY90	15:30	REP TX	29MAY90	7:30	1	LAST LOC; 31MAY90 REC PTT; WL	27.7
382	TPE-01	SPOT	4	9993	PTT	94Y	240	24OCT90	15:30	RETAGGED	13NOV90	15:00	18	LAST LOC; 21NOV90 REC PTT; BOAT	20.0
383	TPE-01	SPOT	0	696	VHF	94Y	220	21NOV90	14:30	RETAGGED	04JAN91	13:20	19	REP TX; TO BETTER UNIT	44.0
384	TPE-01	SPOT	0	720	VHF	58Y	220	04JAN91	13:20	NET REP TX	06JAN91	13:00	19	REP TX; RECEIVER MALFUNCT	2.0
385	TPE-01	SPOT	0	438	VHF	58Y	220	06JAN91	13:00	REP TX	29MAY91	15:00	1	REC TX; WL	143.1
386	TPE-01	SPOT	0	612	VHF	58Y	210	21NOV91	13:30	RETAGGED SAFETY	21NOV91	14:00	30	LAST LOC; TX LOST; WL	0.0
387	TPE-01	SPOT	0	430	VHF	58Y	215	25NOV91	13:30	RETAGGED	15JAN92	16:30	20	REP TX; TO PTT	51.1
388	TPE-01	SPOT	5	9648	PTT	58Y	215	15JAN92	16:30	REP TX	01FEB92	12:00	1	LAST LOC; REC PTT 10FEB92; WL	16.8
389	TPE-01	SPOT	0	720	VHF	58Y	225	09FEB92	9:45	RETAGGED SAFETY	10FEB92	14:30	6	REC TX	1.2
390	TPE-01	SPOT	0	612	VHF	58Y	225	13FEB92	9:45	RETAGGED SAFETY	28FEB92	12:20	20	REP TX; TO PTT	15.1
391	TPE-01	SPOT	6	9645	PTT	58Y	225	28FEB92	12:20	REP TX	18AUG92	16:00	15	REP TX; LOW BATT	172.2
392	TPE-01	SPOT	7	2104	PTT	58Y	225	18AUG92	16:00	REP TX	23NOV92	16:30	15	REP TX; LOW BATT	97.0
393	TPE-01	SPOT	8	9994	PTT	58Y	225	23NOV92	16:30	REP TX	29MAR93	4:00	35	LAST LOC; PTT MIA	125.5
394	TPE-01	SPOT	0	720	VHF	58Y	22	30NOV93	14:30	RETAGGED SAFETY	20DEC93	11:15	20	REP TX; SAFETY TO PTT	19.9
395	TPE-01	SPOT	9	9648	PTT	58Y	47	20DEC93	11:15	REP TX	12APR94	15:50	15	REP TX; LOW BATT	113.2
396	TPE-01	SPOT	10	9644	PTT	58Y	47	12APR94	15:50	REP TX	30MAY94	6:00	1	LAST LOC; 4JUN94 REC TX; WL	47.6
397	TPE-02	FIREBALL	0	646	VHF	15P	225	15FEB89	13:30	FREE TAG	15APR89	19:00	17	REP TX; TX MALFUNCT (BATT FAIL)	59.2
398	TPE-02	FIREBALL	0	355	VHF	15P	210	15APR89	19:00	REP TX SAFETY	18APR89	12:00	19	REP TX; TO TX	2.7
399	TPE-02	FIREBALL	0	800	VHF	15P	210	18APR89	12:00	REP TX	03MAY89	11:15	30	LAST LOC; LOST TX; WL	15.0
400	TPE-02	FIREBALL	0	430	VHF	15P	210	19JUN89	15:00	RETAGGED SAFETY	20JUL89	13:00	20	REP TX; TO PTT	30.9
401	TPE-02	FIREBALL	1	9991	PTT	15P	230	20JUL89	13:00	REP TX	15SEP89	1:00	35	LAST LOC; PTT MIA	56.5
402	TPE-03	SICKLE	0	810	VHF	02P	210	19DEC89	14:50	FREE TAG	10JAN90	11:30	20	REP TX; TO PTT	21.9
403	TPE-03	SICKLE	1	9640	PTT	02P	210	10JAN90	11:30	REP TX	15FEB90	20:01	1	LAST LOC; 16FEB90 REC TX; WL	36.4
404	TPE-03	SICKLE	0	696	VHF	02P	225	17JAN91	16:15	RETAGGED	05FEB91	16:30	17	REP TX; TX MALFUNCT (POOR RANGE)	19.0
405	TPE-03	SICKLE	2	9997	PTT	02P	225	05FEB91	16:30	REP TX	05AUG91	5:00	1	LAST LOC; 7AUG91 REC PTT; WL	180.5

(Appendix 4a continued on next page)

Appendix 4a (continued)

ID	NAME	BOUT	TAGNO	TAG TYPE	BELT	TETHER	ONDATE	ONTIME	ONCOM	OFFDATE	OFFTIME	TERM	OFFCOM	NODAYTAG
406	TPE-03 SICKLE	0	740	VHF	02P	208	25DEC91	16:30	RETAGGED SAFETY	27DEC91	16:30	19	REP TX; TO TX	2.0
407	TPE-03 SICKLE	0	810	VHF	02P	208	27DEC91	16:30	REP TX	28DEC91	16:30	19	REP TX & TETHER	1.0
408	TPE-03 SICKLE	0	740	VHF	02P	230	28DEC91	16:30	REP TX	14JAN92	16:45	20	REP TX; TO PTT	17.0
409	TPE-03 SICKLE	3	9649	PTT	02P	230	14JAN92	16:45	REP TX	27JAN92	12:00	35	LAST LOC; PTT MIA	12.8
410	TPE-03 SICKLE	0	740	VHF	02P	0	12DEC92	12:00	RETAGGED	17DEC92	13:00	20	REP TX; TO PTT	5.0
411	TPE-03 SICKLE	4	9990	PTT	02P	245	17DEC92	13:00	REP TX	08APR93	11:30	16	REP TX; TX MALFUNCT (ANT MISSING)	111.9
412	TPE-03 SICKLE	5	7342	PTT	02P	245	08APR93	11:30	REP TX	27SEP93	6:00	35	LAST LOC; PTT MIA	171.8
413	TPE-04 SUSAN	0	860	VHF	112Y	220	16MAR90	12:00	FREE TAG	23JUL90	12:00	40	RESCUE	129.0
414	TPE-04 SUSAN	1	9993	PTT	113Y	230	21AUG90	9:20	CAP REL	11SEP90	20:31	1	LAST LOC; 13SEP90 REC TX; WL	21.5
415	TPE-04 SUSAN	2	9994	PTT	113Y	220	25OCT90	17:30	RETAGGED	16JAN91	11:20	15	REP TX; LOW BATT	82.7
416	TPE-04 SUSAN	3	9995	PTT	113Y	220	16JAN91	11:20	REP TX	17JUL91	16:30	15	REP TX; LOW BATT	182.2
417	TPE-04 SUSAN	4	9999	PTT	113Y	220	17JUL91	16:30	REP TX	11AUG91	19:38	1	LAST LOC; 12AUG91 REC TX; WL	25.1
418	TPE-04 SUSAN	5	7347	PTT	113Y	.	08SEP94	14:00	RETAGGED	25OCT94	14:20	26	REM TX BLT	47.0
419	TRB-01 SONNY	1	7344	PTT	134FR	22	13FEB92	15:30	FREE TAGGED	12AUG92	14:30	15	REP TX; LOW BATT	181.0
420	TRB-01 SONNY	0	100	VHF	134FR	22	12AUG92	14:30	REP TX SAFETY	18AUG92	13:30	20	REP TX; SAFETY TO PTT	6.0
421	TRB-01 SONNY	2	2103	PTT	134FR	22	18AUG92	13:30	REP TX	18NOV92	17:00	6	LAST LOC; SAFETY FAILURE AT SWITCH	92.1
422	TRB-01 SONNY	3	7341	PTT	134FR	0	14DEC92	11:45	RETAGGED	24JUN93	15:30	1	REP TX; LOW BATT	192.2
423	TRB-01 SONNY	0	511	VHF	134FR	0	24JUN93	15:30	REP TX SAFETY	25JUN93	12:30	20	REP TX; TO PTT	0.9
424	TRB-01 SONNY	4	4025	PTT	134FR	0	25JUN93	12:30	REP TX	04JAN94	11:40	15	REP TX; LOW BATT	193.0
425	TRB-01 SONNY	5	9999	PTT	134FR	0	04JAN94	11:40	REP TX	17JAN94	12:30	16	REP TX; MALFUNCT (POOR SIG)	13.0
426	TRB-01 SONNY	6	4024	PTT	134FR	0	17JAN94	12:30	REP TX	13APR94	10:15	15	REP TX; LOW BATT	85.9
427	TRB-01 SONNY	7	2100	PTT	134FR	0	13APR94	10:15	REP TX	24OCT94	16:05	15	REP TX; LOW BATT	194.2
428	TRB-01 SONNY	8	9999	PTT	134FR	0	24OCT94	16:05	REP TX	21APR95	15:00	15	REP TX; LOW BATT	179.0
429	TRB-01 SONNY	9	7340	PTT	134FR	56	21APR95	15:00	REP TX	24OCT95	16:45	15	REP TX; LOW BATT	186.1
430	TRB-01 SONNY	10	20208	PTT	134FR	56	24OCT95	16:45	REP TX	01AUG96	11:55	15	REP TX; LOW BATT	220.3

Variable labels:

- ID = Manatee identification number.
- NAME = Manatee name.
- BOUT = Tagging bout number (bout = 0 for VHF tags).
- TAGNO = Tag number (VHF < 1000, PTT ≥ 1000).
- TAGTYPE = PTT or VHF tag.
- BELT = Belt size and color.
- TETHER = Tether strength.
- ONDATE = Date tag deployed.
- ONTIME = Local time tag deployed.
- ONCOM = Comments on deployment.
- OFFDATE = Date tag detached.
- OFFTIME = Local time tag detached.
- TERM = Termination code: why tag detached (see Appendix 4b).
- OFFCOM = Comments on detachment.
- NODAYTAG = Tagging bout duration days) to 31 May 1996.

Appendix 4b. Explanation of TERM Codes and Off Comments in the tagging history lookup table (Appendix 4a) for the causes for tagging bout termination.

Term Code	Fate and Cause of End to Tagging Bout	Off Comment
0	Manatee Recovered Dead Wearing Transmitter	DEAD
	Recovered Transmitter	
1	Weak-link broken	WL
2	Weak-link broken by human	WL (HUMAN)
3	Weak-link broken by alligator	WL (ALLIGATOR)
4	Other at transmitter or tether; eyebolt broken, tether broken	(various)
5	Other at belt; buckle swivel failed	(various)
6	Other human caused; small connector unscrewed, safety failed	(various)
7	Boat strike	BOAT
	Recovered Tag (belt and transmitter)	REC TX BLT
10	Belt broken	BELT BROKEN
	Replaced Transmitter	REP TX
15	Low battery life remaining	LOW·BATT
16	Malfunction with housing; antenna missing, leaked, barnacles	MALFUNCT (various)
17	Malfunction with electronics; batteries died prematurely, poor range, failed	MALFUNCT (various)
18	Boat strike	BOAT
19	To better unit	(various)
20	To PTT	TO PTT
	Replaced Tag (belt and transmitter)	REP TX BLT
25	Belt worn out or swivel failed	(various)
26	Removed Tag (belt and transmitter)	REM TX BLT
	Transmitter Lost	TX LOST
30	Missing at weak-link	WL
31	Missing at weak-link; assume boat strike	WL; BOAT
35	Transmitter Missing; Manatee Not Resighted	TX MIA
40	Manatee Rescued	RESCUE
77	PTT Accuracy Test Unit	PTT TEST
99	PTT Unit still on Manatee	ON

Appendix 5. Definitions of manatee activity categories and database codes for VHF radio-telemetry data collection and data entry.

CODE	ACTIVITY	DESCRIPTION
R	**Rest**	Resting at or below the surface; stationary. Two subcategories of resting (A, B) are given below. Includes comfort movements (e.g., pectoral scratch, back rub).
*** A**	**Surface Rest**	Resting (perhaps sleeping) at the surface with back exposed; tail & flippers hang down; generally breathing at 4+ minute intervals. [Termed "suspended resting" by Hartman (1979).]
*** B**	**Bottom Rest**	Resting (perhaps sleeping) under the surface; includes resting on the bottom or in the water column (subsurface); generally breathing at 4+ minute intervals.
M	**Mill**	Slow non-directed travelling in same general area. [Formerly referred to in database as "Idling" (code "I") by DEE, RKB & ST, as "Loitering" (code "L") by JPR, or as Milling by BZ.]
T	**Travel**	Steady movement in one general direction at slow, moderate or fast speed.
*** U**	**Slow Travel**	Steady movement in one general direction at a slow speed; tag stays at surface. [Classified as "Idling" by J. Reid; slow swimming (2-3 km/hr) called "Idling" by Hartman (1979).]
*** V**	**Fast Travel**	Steady movement in one general direction at a moderate to fast speed; tag is pulled below surface frequently or for considerable periods of time.

D	**Drink**	Drinking fresh water; note source of water (e.g., hose, A/C pipe, sewage effluent, stream) on tracking map.
F	**Feed**	Feeding on the bottom (e.g., muddy water displaced), on the surface (e.g., pulling down floating vegetation, flotsam), or on the shoreline (e.g., grass, overhanging bushes). Head sometimes raised above surface with vegetation visible in mouth or chewing during breath; generally breathing at 1 - 3 minute intervals. Document vegetation type and feeding mode.
* H	**Human Feed**	Consuming food given by humans (excluding researchers); record type & amount of food.
S	**Socialize**	Interacting with other manatees, including nuzzling, "kissing", rubbing, and other "low-energy" behaviors; excludes cavorting. Includes most mother-calf interactions. [Also known as "Mildly cavorting" (Zoodsma 1991).]
C	**Cavort**	Intense socializing with one or more other manatees, including grabbing with flippers (embracing), rolling, splashing, chasing and/or much physical contact. Includes sexual activity (heterosexual & homosexual).
* Z	**Mating Herd**	Animal is part of a mating herd, defined as follows: a group of two or more manatees (presumably males) persistently following and interacting with a single "focal" animal (presumably an estrous female) over a sustained period of time (typically days to weeks). General activity of the group tends to mirror that of the focal animal (e.g., group rests/mills when female bottom-rests; courtship activity resumes when female becomes active). Female may "strand" in very shallow water, apparently attempting to evade male escorts. Actual activities may include resting, milling, travelling, feeding, socializing, cavorting, or copulating. These activities should also be recorded. For females, the mating herd code is used only if she is the focal animal. [Termed "estrous herd" by Hartman (1979)].

N	**Nurse**	Tagged cow nursing her calf or tagged calf suckling from its mother. Calf below surface with head touching and under mother's axilla.
* **G**	**Birth**	Tagged female gives birth to calf. Restricted to actual observation of birth, or if apparent that female has just given birth (e.g., blood or placenta in water) within the hour.
O	**Other Activity**	Any other activity; currently used only for researcher tagging interaction (i.e., initial capture, tag & release; retag; unsuccessful attempt at retagging), indicating possible disturbance.
X	**Unknown**	Activity unknown or not recorded. For example, an animal is stationary but could be feeding or resting.

* Denotes new or modified activity codes.

Observers: BZ = Barbara Zoodsma, DEE = Dean Easton, JPR = James Reid, RKB=Robert Bonde, ST = Sharon Tyson.

Sources: Hartman (1979); Bengtson (1981); Zoodsma (1991); Puerto Rico captive manatee activity data sheet (R. Bonde, pers. comm.).

Appendix 6. Preliminary assessment of the precision (i.e., repeatability) associated with digitizing manatee point locations. This was based on a small number of points in the Sharpes quadrangle, close to the FPL Canaveral power plant in Brevard County. Since this small, non-random sample is not likely to be representative of the VHF database as a whole, caution is necessary in interpreting these findings.

The preliminary conclusions are as follows:

(1) Locations may be digitized with approximately equal precision and accuracy on hardcopy maps and on-screen in Arcview; the two methods differed by an average of about 20-25 m (1.0 mm on a 1:24,000 scale quad map).
(a) For a best case scenario, S. Butler and C. Deutsch each digitized five points that were located at easily discernible landmarks (e.g., tip of FPL breakwater) and found that the mean absolute differences (± SD, min-max) were 10 m (±9, 2-22) and 14 m (±7, 6-24) for X and Y UTM coordinates, respectively. There was no directional bias, with the mean differences (including + and - signs) close to zero. The mean euclidean distance between locations was 18.5 m.
(b) For a more realistic scenario, we each digitized five actual locations in the FPL area. The mean absolute differences (± SD, min-max) were very similar to the above result: 18 m (±16, 4-42) and 14 m (±5, 6-19) for X and Y UTM coordinates, respectively. Again, there was no apparent directional bias, with the mean differences (including + and - signs) close to zero. The mean euclidean distance between locations was 25.4 m.

(2) The repeatability (or precision) with which VHF locations are digitized may be poorer than we anticipated. For four locations in March 1988 that S. Butler redigitized, the mean absolute differences (± SD, min-max) were 130 m (±66, 43-192) and 48 m (±34, 20-91) for X and Y UTM coordinates, respectively. Two of the X coordinate pairs differed by +170 and -192 m, while the Y coordinate pairs differed by at most +61 and -91 m, so there was no obvious directional bias such as might be caused by improper map registration prior to digitizing. The original digitization was not done by S. Butler. This comparison needs to be repeated with a much larger sample size over a number of areas to estimate digitizing precision with a higher degree of confidence.

Appendix 7. Report on tagged manatee use of the Cocoa Beach / Thousand Islands area (mid-Banana River, Brevard County) from 1992 to 1995 presented to the Bureau of Protected Species Management, Florida Department of Environmental Protection.

Tagged Manatee Use of the Cocoa Beach / Thousand Islands Area

Data Summary by Dr. Charles J. Deutsch
Sirenia Project, National Biological Service
11 April 1996

Study Period included in Analysis: 1 Jan 1992 to 30 Sep 1995
Data Type: Platform Transmitter Terminal (PTT) locations determined via satellite (Service Argos). VHF data were not included.
Location Class: 2 & 3 only.

Note about accuracy: Approximately 2/3 of given locations are within 350 m (LC2) and 150 m (LC3) of the actual locations (i.e., one error SD), according to Service Argos.

Procedures and Qualifications

I restricted the analysis to all locations of the 25 manatees that were recorded at least once in the Banana River during the study period. The resulting database contained 19,277 locations (LC2 & LC3); this was condensed to only one location per day, for a total of 7922 "manatee-days." The attached tables give the number of manatee-days in the areas delineated by you: MinuteMan (MM) (the proposed watersports area); Cocoa Beach / Thousand Islands (CB); Banana River (BR); and total days tracked throughout the entire range. Note that the values presented for these areas are inclusive; for example, the number of manatee-days in the Cocoa Beach area includes the number of manatee-days in the MinuteMan area. I included data for the entire BR in order to put the CB data into perspective. The data are pooled across sexes (10M:15F), age classes (19AD:6SU) and rehabilitation status (15 Wild : 5 Short-term Rehab : 5 Long-term Rehab), but wild-caught adult females make up the single largest group in the sample (n=11). The mean (± SD) duration of satellite-tracking (i.e., no. of days with LC2 or LC3 locations) was 317 (± 325) days, but this varied greatly among individuals (range, 12 - 1091 days). Some manatees (e.g., TBC-09, TBC-24, TRB-01) were tracked for over 1000 days, or nearly continuously during the 3½-year time period, while others were tracked for short periods. The latter included three captive-born manatees (TBC-45, -46, -47) released from the acclimation pen in the upper Banana River in late August 1995, one month prior to the end of the current database; other tagged animals made only brief visits to BR (e.g., TBC-37, TFP-06, TMI-03) or lost their PTTs soon after tagging (e.g., TBC-43). Six manatees included in the database were located on less than 60 days over the study period; excluding data from these animals, the mean tracking duration was 407 (± 324) days. An additional four manatees were located in BR on less than 60 days. The statistics presented below are based on the entire sample of 25 manatees; for some analyses, these are followed by statistics in brackets [ ] for the sample of 19 manatees with at least 60 days of locations and by statistics in brackets { } for the sample of 15 manatees with at least 60 days of locations in BR.

Overall Use of Cocoa Beach / Thousand Islands Area

For all animals and months pooled, 57.4% of total manatee-days were spent in the Banana River (Table p. 7). On an individual basis, 64% (16/25) of tagged manatees spent at least half of their total days tracked in the BR [53% (10/19)] {67% (10/15)}.

For all animals and months pooled, 10.6% of BR manatee-days were spent in the Cocoa Beach / Thousand Islands zone (Table p. 7). For comparison, the area of CB (25.76 km^2) is 7.7% of the area of the entire BR (336.12 km^2). On an individual basis, 64% (16/25) of tagged manatees were located at least once in CB [74% (14/19)] {73% (11/15)}. 40% (10/25) of the animals spent at least 10% of their days in the BR in the CB zone [47% (9/19)] {40% (6/15)}, and 8 [7] {7} of these were located in CB on 20 or more days (max = 167 days).

For all animals and months pooled, 1.4% of BR manatee-days were spent in the Minuteman area that has been proposed as a watersports zone (Table p. 7). The area of MM (5.76 km^2) is 1.6% of the area of the entire BR. On an individual basis, 36% (9/25) of manatees were located at least once in MM [42% (8/19)] {47% (7/15)}. 24% (6/25) of the manatees spent at least 2% of their days in the BR in the MM zone [26% (5/19)] {27% (4/15)}, and 5 [4] {4} of these animals were located in MM on 6 or more days (max = 17 days).

Seasonal Use of Cocoa Beach / Thousand Islands Area

Tagged manatee use of the Banana River varied seasonally, with low use in winter months (Dec - Feb) and high use during most of the rest of the year (Apr - Nov) (Table, p. 6 -- data for all individuals pooled into manatee-days). Most of the animals spent the winter in South Florida or in the Indian River near the two power plants (FPL & OUC); they typically moved into the Banana River in March and April. Restricting the analysis to just those manatees with at least 10 days of tracking data in a given month, the following percentages of tagged manatees were present at least one day in the BR by month:

Jan	23% (n=13)	May	79% (n=14)	Sep	79% (n=19)
Feb	21% (n=14)	June	89% (n=18)	Oct	93% (n=14)
Mar	60% (n=15)	July	79% (n=19)	Nov	77% (n=13)
Apr	79% (n=14)	Aug	69% (n=16)	Dec	42% (n=12)

Use of the Cocoa Beach area likewise showed marked fluctuations across months, with distinct peaks in the spring (Apr, May, June) and fall (Sep, Oct, Nov) (Table, p. 6 -- data for all individuals pooled into manatee-days). Restricting the analysis to just those manatees which spent at least 10 days in the BR in the given month, the following percentages of animals were present at least one day in the CB area by month:

Jan	0% (n=1)	May	67% (n=9)	Sep	40% (n=15)
Feb	50% (n=2)	June	55% (n=11)	Oct	58% (n=12)
Mar	57% (n=7)	July	46% (n=13)	Nov	60% (n=10)
Apr	40% (n=10)	Aug	60% (n=10)	Dec	25% (n=4)

Note that the small numbers of manatees using the BR regularly in winter (Dec-Feb) mean that the corresponding percentages of animals using CB during this season have little meaning. Of the 193 manatee-days logged in the BR for the three winter months, only 3 (1.6%) were located in the CB zone (Table, p. 6). These 3 represent only 0.6% of the 483 manatee-days recorded in CB. It is clear that our sample of tagged manatees rarely used CB during the winter period.

Use of the Minuteman zone followed a similar pattern to that of the larger CB area, with higher use occurring in spring (Apr, May, Jun) and fall (Oct, Nov) (Table, p. 6 -- data for all individuals pooled into manatee-days). Restricting the analysis to just those manatees which spent at least 10 days in the BR in the given month, as above, the following percentages of animals were present at least one day in the MM area by month:

Jan	0% (n=1)	May	33% (n=9)	Sep	0% (n=15)
Feb	0% (n=2)	June	36% (n=11)	Oct	25% (n=12)
Mar	29% (n=7)	July	8% (n=13)	Nov	20% (n=10)
Apr	30% (n=10)	Aug	0% (n=10)	Dec	0% (n=4)

The tagged manatees were not located in the MM zone in winter (Dec-Feb) and only once in July, August and September. The small overall sample size (total of 62 manatee-days), however, makes conclusions about seasonal usage patterns more tentative.

Conclusions

Approximately ⅔ to ¾ of the tagged manatees in our sample were located in the Cocoa Beach / Thousand Islands area, as delineated on the attached map. The area was used to a considerable extent during the periods of spring/early summer (April to June) and fall (September to November). These roughly correspond to the end and the beginning of the spring and fall migratory periods, respectively. Tagged manatees rarely used the area in the winter months (December - February) and, for unknown reasons, there was an apparent lull in use in the mid-summer (July - August). Qualitatively, we know that the residential canals and other protected waterways in this area (especially to the north in the Ten Thousand Islands part) are used by manatees for resting, and that they often move offshore to feed on seagrass beds; a favorite foraging ground is in open water along the southern edge of the Cocoa Beach zone.

The small size of the proposed watersports zone south of the Minuteman causeway makes firm conclusions more difficult. About ⅓ to ½ of the tagged manatees were located in this area over the study period, with a seasonal pattern similar to that of the Cocoa Beach area as a whole. The Minuteman area did not appear to be a hotspot of tagged manatee use, but it is likely that manatees passed through or near this zone when travelling between important foraging and resting areas to the north and south; further more detailed analyses would be required to examine potential travel routes. The radio-tag is usually underwater when a manatee is travelling, and so the tag generates few (or poorer quality) locations in this situation. Therefore, the telemetry data cannot directly be used to assess whether manatees are travelling through the small zone of interest, although manipulation of the data with cost-path analyses (as is being developed by FDEP researchers at FMRI) can produce models of potential travel corridors. Aerial survey data would also be helpful to determine frequency of use by active manatees in this area.

SATELLITE TELEMETRY LOCATIONS OF BANANA RIVER MANATEES
SIRENIA PROJECT PTT DATA: Location Class 2 & 3 ONLY
January 1992 - September 1995
Determined from Arcview 2.1 (dBase3 file)

Spatial Use by MONTH: ALL MANATEES POOLED

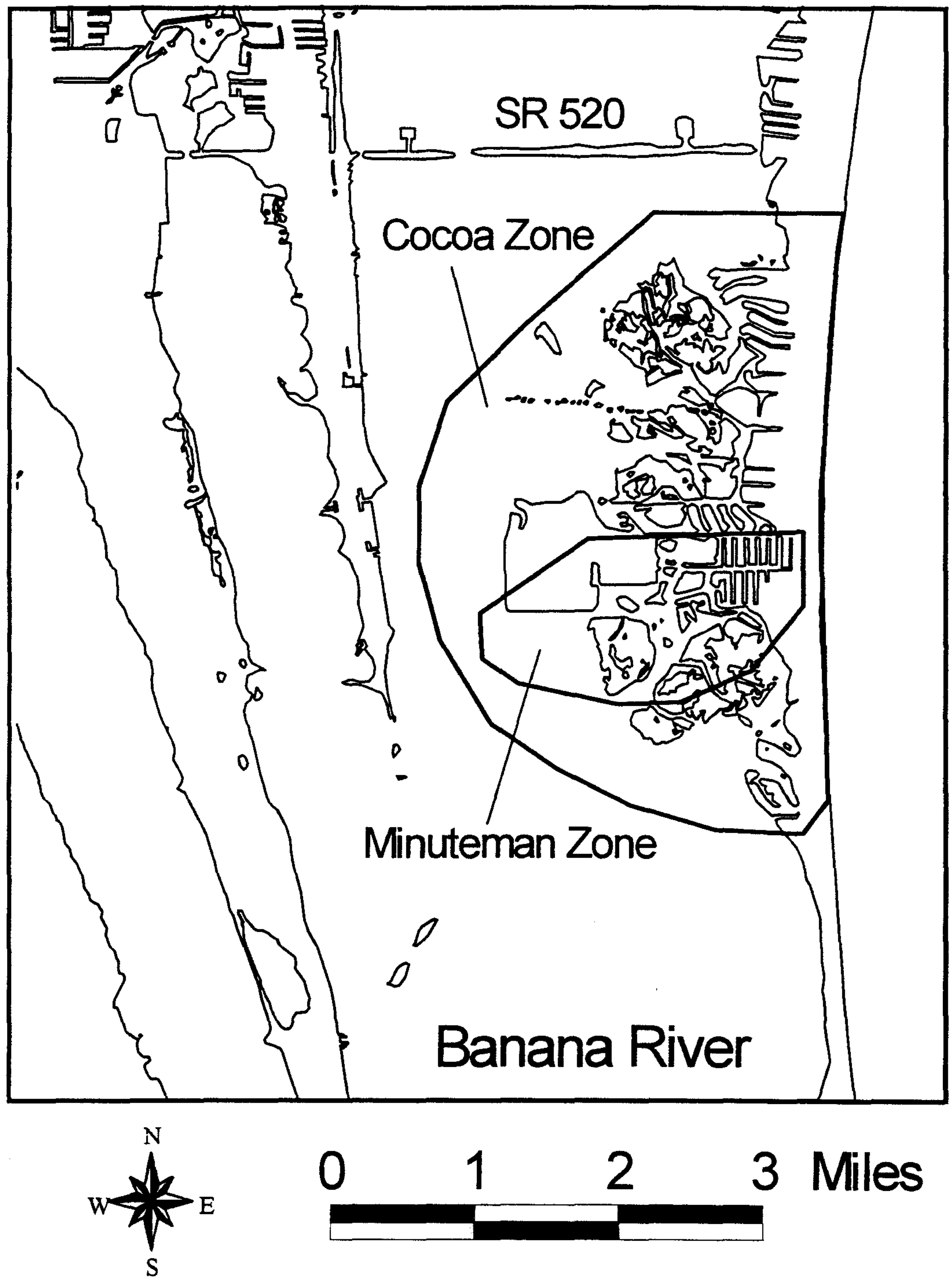
MONTH	MinuteMan (no. days)	CocoaBeach (no. days)	BananaRiver (no. days)	Total (no. days)	MINMAN/COCOA (% days)	MINMAN/BANRIV (% days)	COCOA/BANRIV (% days)	BANRIV/TOTAL (% days)
ALL	62	483	4544	7922	12.8	1.4	10.6	57.4
JAN	0	1	41	630	0.0	0.0	2.4	6.5
FEB	0	1	65	621	0.0	0.0	1.5	10.5
MAR	2	7	357	730	28.6	0.6	2.0	48.9
APR	12	43	519	740	27.9	2.3	8.3	70.1
MAY	17	74	476	737	23.0	3.6	15.5	64.6
JUN	11	96	524	745	11.5	2.1	18.3	70.3
JUL	1	16	579	761	6.3	0.2	2.8	76.1
AUG	0	10	520	702	0.0	0.0	1.9	74.1
SEP	0	50	586	744	0.0	0.0	8.5	78.8
OCT	13	134	475	571	9.7	2.7	28.2	83.2
NOV	6	50	315	496	12.0	1.9	15.9	63.5
DEC	0	1	87	445	0.0	0.0	1.1	19.6

SATELLITE TELEMETRY LOCATIONS OF BANANA RIVER MANATEES
SIRENIA PROJECT PTT DATA: Location Class 2 & 3 ONLY
January 1992 - September 1995
Determined from Arcview 2.1 (dBase3 file)

Spatial Use by MANATEE: ALL MONTHS POOLED

Tagged Manatee ID	MinuteMan (no. days)	CocoaBeach (no. days)	BananaRiver (no. days)	Total (no. days)	MINMAN/COCOA (% days)	MINMAN/BANRIV (% days)	COCOA/BANRIV (% days)	BANRIV/TOTAL (% days)
ALL	62	483	4544	7922	12.8	1.4	10.6	57.4
TBC-03	0	28	254	428	0.0	0.0	11.0	59.3
TBC-09	0	3	760	1091	0.0	0.0	0.4	69.7
TBC-24	17	106	739	1035	16.0	2.3	14.3	71.4
TBC-26	10	34	172	307	29.4	5.8	19.8	56.0
TBC-32	2	26	83	83	7.7	2.4	31.3	100.0
TBC-35	0	1	38	44	0.0	0.0	2.6	86.4
TBC-36	1	35	290	434	2.9	0.3	12.1	66.8
TBC-37	0	1	6	289	0.0	0.0	16.7	2.1
TBC-38	0	0	66	195	.	0.0	0.0	33.8
TBC-41	0	0	99	141	.	0.0	0.0	70.2
TBC-42	0	1	63	152	0.0	0.0	1.6	41.4
TBC-43	0	0	10	12	.	0.0	0.0	83.3
TBC-44	0	0	103	104	.	0.0	0.0	99.0
TBC-45	0	0	25	26	.	0.0	0.0	96.2
TBC-46	0	0	31	32	.	0.0	0.0	96.9
TBC-47	0	0	27	27	.	0.0	0.0	100.0
TFP-06	0	1	10	587	0.0	0.0	10.0	1.7
TMI-01	2	8	133	314	25.0	1.5	6.0	42.4
TMI-02	0	0	138	442	.	0.0	0.0	31.2
TMI-03	1	1	8	119	100.0	12.5	12.5	6.7
TNC-10	0	0	57	193	.	0.0	0.0	29.5
TPE-01	17	167	342	494	10.2	5.0	48.8	69.2
TPE-03	0	3	90	272	0.0	0.0	3.3	33.1
TPE-04	6	38	43	43	15.8	14.0	88.4	100.0
TRB-01	6	30	957	1058	20.0	0.6	3.1	90.5

N = 26



Cocoa Beach / Thousand Islands Study Area.
Two zones mentioned in the text are delineated. The proposed watersports area lies within the Minuteman zone.